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Stuart G. Hibben

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13. ABSTRACT

This report includes abstracts and bibliographic lists on contractual subjects that were completed in May, 1973. The major topics are: laser technology, effects of strong explosions, geosciences, particle beams, and material sciences. A section on items of miscellaneous interest is also included.

Laser coverage is generally limited to high power effects; all current laser material is routinely entered in the quarterly laser bibliographies.

An index identifying source abbreviations and a first-author index to the abstracts are appended.

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INTRODUCTION

This report includes abstracts and bibliographic lists on contractual subjects that were completed in May, 1973. The major topics are: laser technology, effects of strong explosions, geosciences, particle beams, and material sciences. A section on items of miscellaneous interest is also included.

Laser coverage is generally limited to high power effects; all current laser material is routinely entered in the quarterly laser bibliographies.

An index identifying source abbreviations and a first-author index to the abstracts are appended.

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1. Laser Technology

A. Abstracts

Zverev, G. M., V. S. Naumov, and V. A. Pashkov. Self-focusing of ultrashort laser pulses in solid dielectrics. FTT, no. 2, 1973, 575-576.

A brief description is given of filament formation from self-focusing in several dielectrics, including fused and crystalline quartz, leucosapphire and type K-8 glass. A mode-locked Nd glass laser was used, generating 5 picosecond bell-shaped pulses with a 17 nsec repetition rate. A combination of a Pockels cell and a nitrogen gas switch was used to segregate one or more pulses, which were amplified to 0.03 j and focused in the target at 6.5 and 20 cm focal lengths. The discussion is mainly on the difference in filament formation from a single vs. multiple pulses; Fig. 1 is a typical result, showing successive variation

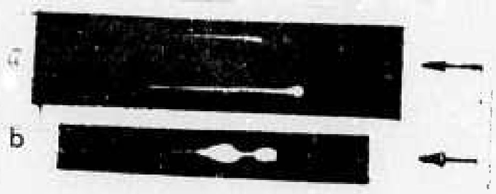

Fig. 1. Filament formation from ultrashort pulses. a- in quartz and sapphire, single pulse; b- in quartz, two pulses. Arrows show incident radiation; f = 6.5 cm, photos x 15.

in the self-focus point. With the focal length at f = 20 cm, filaments on the order of 2 cm long were observed. Additional data are given showing filament growth and progression toward the focusing lens as pulse power is increased, and the progressive breakdown mechanism is discussed qualitatively.

Lugovoy, V. N., and A. M. Prokhomov. Heating and confinement of plasma in crossed light beams. ZhETF P, v. 17, no. 1, 1973, 52-55.

A new method of plasma heating by a pulsed laser radiation is introduced to produce a nuclear fusion reaction. The method consists of heating a material by two beams, e.g., emitted by the same laser, intersecting at some angle α. In contrast to previously discussed techniques, this method enables heating the plasma much longer than the time of hydrodynamic dissipation, and obtains a skin layer area much larger than the surface area of the heated plasma volume.

Interference of the two-focused beams intersecting near their focal regions of diam. $d\Phi_1$ and $d\Phi_2$ produces three-dimensional "microregions" or potential wells which prevents plasma dissipation if the electromagnetic field pressure p_{lim} on the boundary surface of a microregion is greater than plasma pressure p_{pl}. Assuming the condition $p_{lim} > p_{pl}$ holds within the time interval $(t_1 - t_o)$, where t_o is the time of total ionization, the time dependence of power $p_1(t)$ is shown to be exponential for a typical laser pulse. The above assumption is then valid, if the pulse duration

$$\tau_{и} < \tau(1) = \frac{3V}{c\, d_{\Phi}^{2} \mu} \quad (1),$$

where V is the total plasma volume confined to the microregions, $d\Phi = \max(d\Phi_1, d\Phi_2)$, and μ is the efficiency of optical energy conversion into thermal energy. Plasma temperature T_1 at maximum p_1 is given by

$$T_1 = \frac{\mu}{6nkV} E_{л} , \quad (2),$$

where n is the ion density and E_l is the total energy in the laser pulse. Application of (1) and (2) to a D-T plasma ($n = 5x10^{22} cm^{-3}$) heated by laser pulses with $E_l = 3x10^4$ j and $\mu = 10^{-1}$ gave $\tau_p < 10^{-9}$sec. and $T_l = 3x10^7$ deg. Free dissipation time of the plasma with $d\Phi = 5x10^{-3}$cm. would be $4x10^{-11}$sec, i.e. an order of magnitude shorter than τ_p. Plasma confinement is feasible even for the case when material layer thickness ℓ is significantly smaller than the length of microregions, provided $\ell >> \nu_s \tau_p$, where ν_s is the sound velocity in the plasma. Shorter laser pulses, e.g., $\tau_p = 3x10^{-11}$sec, would promote a greater plasma contraction and increase n in the microregions.

Fonkich, M. Ye., I. S. Lutsik, B. T. Piven', and M. V. Sidenko. Effect of longwave laser radiation on latent images. ZhNiPFiK, no. 6, 1972, 465-467.

The dissipative effect of GaAs laser radiation at $\lambda = 850$ mμ on the latent image in an SP-1 plate and type FT 30 or MZ-3 photographic films was studied by a sensitometric technique. The radiation power density and duration of laser beam interaction with the emulsion were varied over $1:10^3$ and $1:10^2$ ratios, respectively. In contrast to the effect of red thermal sources, laser irradiation at increasing duration and intensity caused a shift of the equilibrium optical density D_H position towards higher densities on the characteristic curve. Nearly total dissipation of the latent image can be achieved by exposure to laser beams for times 3 or 4 orders of magnitude shorter than with thermal sources. The specificity of the laser effect is attributed to a two-photon process. The optical density is also found to decrease nonlinearly with decrease in laser beam power density.

Betaneli, A. I., L. P. Danilenko, T. N. Loladze, Ye. F. Semiletova, B. M. Zhiryakov, and A. K. Fannibo. Feasibility of supplementary alloying of R-18 steel surfaces by laser beam. FiKhOM, no. 6, 1972, 22-26.

Experimental data were obtained on localized surface alloying of R-18 high-speed steel by a quasi-cw pulsed ruby laser beam. Graphite and VK-3, VK-6, or T15K6 standard mixtures for hard alloys were used as source alloying elements to test the feasibility of developing a steel-base tool with improved cutting and wear resistance characteristics. A 10^{-3} sec duration laser pulse was used at 15 and 25 j output energies and 10^5 to 5×10^6 w/cm^2 power densities. The exposed region was conditionally divided into a fused zone and an adjacent transitional zone (Fig. 1).

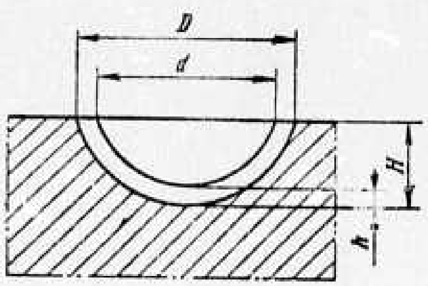

Fig. 1. Shape and parameters of irradiated region.

Tabulated D, d, H, and h values (D- heat treatment region diameter, d- fusion diameter, H- heat treatment region depth, and h- quenching region) varied as functions of radiation energy and power density, and material composition. D may be increased and H decreased by varying the power density. No craters, ablation or any sign of specimen destruction, even at a power density of 10^6 w/cm^2 was observed. A localized spectrum

analysis indicated a significant change in the chemical composition of the irradiated volume; e. g. increases in the carbon or tungsten contents of the metal. Micrographs of the etched surface reveal the microstructure of the melt. Depth microhardness data (Fig. 2) show that the transitional

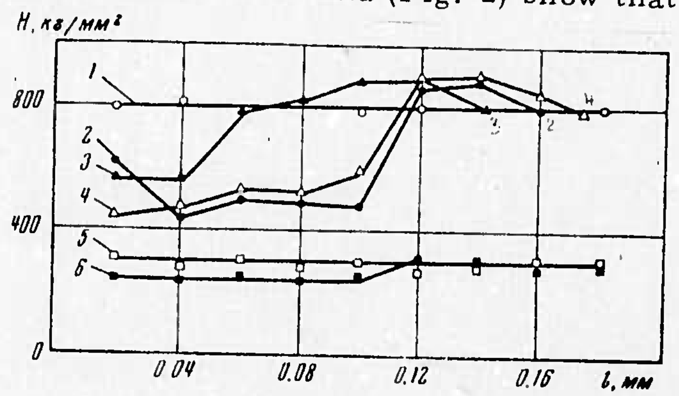

Fig. 2. Microhardness distribution in irradiated region of a P-18 plus BK6 composition: 1 - non-irradiated, hardened control specimen; 2, 3, 4 - specimens irradiated at 10^6, $5x10^5$, and 10^5 w/cm^2 power densities, respectively; 5 and 6 - nonirradiated steel specimens annealed at 650° and 850 °C.

or region of secondary hardening exhibits maximum hardness. Zones of varying hardness at differing depths can be obtained by selecting a suitable irradiation regime. Hardness increased after heat-treatment of irradiated specimens. Analysis of Debye powder diagrams of specimens irradiated at $5x10^5$ - 10^6 w/cm^2 and air-cooled indicates a characteristic increase of the α-Fe lattice parameter. The authors conclude that lattice expansion is due to the alloying elements and the carbides dissolved in the matrix material.

Supplemental surface alloying of a high alloy steel by laser beam was thus found to be feasible. The resulting alloy composition depends on the powder used for alloying and the beam parameters. The selection of a quasi-cw irradiation regime is justified by the ease of controlling radiation parameters and the absence of metal destruction.

Basov, N. G., E. M. Belenov, V. A. Danilychev, O. M. Kerimov, and I. B. Kovsh. Optical breakdown in compressed gases from CO_2 laser radiation. ZhETF, v. 63, no. 6, 1972, 2010-2014.

The optical strength of atomic and molecular compressed gases was studied theoretically and experimentally, to determine the breakdown threshold parameters of IR laser emission in gases under $\sim$100 atm. pressure. Optical breakdown in compressed gases by a laser beam is treated as a cumulative ionization process. In the case of atomic or molecular gases at pressures $p \geq 1$ atm and relatively high laser radiation power density q(p) the ion cumulation constant is given by

$$\gamma = k/\tau, \tag{1}$$

where $\tau = I/\alpha$ is the characteristic time in which the laser energy accumulates on an electron in the amount ϵ nearly equal to the atomic ionization potential I, and k is the probability of electron transit through the excitation zone of electron therms. At higher p, the bremsstrahlung effect on excitation of vibrational molecular levels must be taken into account in calculation of γ. Then the expression for γ becomes

$$\gamma = k\Omega \exp\left\{-\frac{3}{2}\frac{\alpha^{*}(i)\,\Delta}{\alpha i}\right\}, \tag{2}$$

where $\Omega = i/\alpha$ is the frequency of electron inversion in the energy zone [O, i], $\alpha^{*}(\epsilon) \sim \alpha^{**}i)\,\Delta\,\delta(\epsilon - i)$ is the rate of electron losses in vibrational excitation, i is the energy corresponding to $\alpha^{*}(\epsilon)$ maximum, and Δ is the characteristic "width" of the $\alpha^{*}(\epsilon)$ function.

Experiments were done in which breakdown in compressed gases was induced by 0.5 j pulses from an electrically ionized CO_2-N_2 laser, generating at p = 2 atm. The laser beam was focused by a spherical mirror into a chamber filled with gas under 1-60 atm. pressure. Power measurements showed that the optical breakdown threshold q^* in all gases studied at 1-10 atm pressure decreases with increased p (Fig. 1). At p > 10 atm,

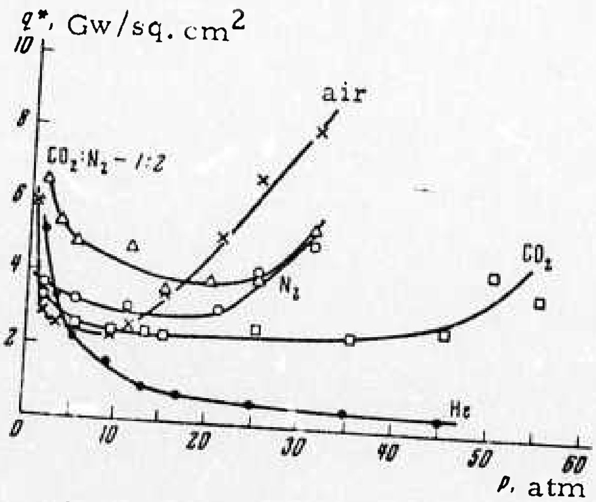

Fig. 1. Threshold intensity of optical breakdown in compressed gases from CO_2 laser radiation, vs. pressure.

q* in molecular gases increases rapidly, but q* in He up to 50 atm does not increase. At high field potentials ($\alpha \geq \alpha^*$), optical strength of a gas is determined, according to (1), by the laser pulse energy W*. The calculated W*(p) minimum for breakdown in He corresponds to p ~ 30 atm, while the experimental curve in Fig. 1 indicates saturation of q*(p) at p ~ 40 atm. The optical strength of a molecular gas is determined, according to (2), by radiation power. For N_2 at p = 1 atm, $q^* = 10^9$ w/cm^2 from (2) and $q^* = 10^7$ w/cm^2 from (1). It is concluded that, at low p, q* = Q*(p) is a slowly decreasing function, whereas at high p Q* increases as p^2. Using N_2 as an example, q*(p) for $\lambda = 10\mu$ radiation starts to increase rapidly from p = 20-30 atm.

Letokhov, V. S., and A. A. Makarov. Vibrational excitation kinetics of molecules by infrared laser radiation. ZhETF, v. 63, no. 6, 1972, 2064-2076.

Selective excitation of vibrational degrees of freedom by powerful IR laser pulses is analyzed. Results show that, at a high excitation power, saturation of even the first vibrational level of a molecule takes at least τ_{rot}/q, where τ_{rot} is the rotational relaxation time and q is the fraction of molecules excited to the same rotational level. This "bottleneck effect" is shown to essentially restrict the resonance excitation rate of a molecular system to higher vibrational levels. This restriction of the accumulation rate of vibrational energy E exists in both excitation models examined (by successive transitions and by vibration-vibrational exchanges). The nonequilibrium distribution function u (x, t) of vibrational levels is formulated for both models. In the most general case, due to the bottleneck effect the E transferrable to a molecular system is restricted by the relation

$$(h\omega)^{-1}\ dE/dt < q/2\tau_{rot},$$

where $h\omega$ is the transition energy. The authors conclude that the restriction on the excitation rate of molecular vibrations seriously impedes selective vibrational heating of the molecules, and consequently the promotion of selective chemical reactions by monochromatic IR laser radiation.

Rayzer, Yu. P. Discharge propagation and confinement of a dense plasma by electromagnetic fields. UFN, v. 108, no. 3, 1972, 429-463.

This is an up-to-date systematic review and analysis of known experimental and theoretical research data on continuous discharge plasma generation, and its confinement in an electromagnetic field. Soviet sources comprise 75% of the 55 references. The data reviewed are divided into three main groups according to the type of discharge propagation regime: supersonic shock wave, subsonic equilibrium heat conduction, and nonequilibrium ionization wave regimes. An analogy is drawn between the different discharge propagation regimes and detonation or slow burning mechanisms of combustion. Thus, the supersonic propagation of the laser plasma front in air is related to optical detonation, which may be treated as a hydrodynamic discontinuity by analogy with a detonation wave in combustion.

Flow propagation, e.g. at $\approx$40 m/sec, of the plasma front initiated by a spark discharge in air, and maintained by a focused laser beam with subthreshold intensity, is interpreted as a slow burning of the laser beam. In this case, the optical discharge propagates by a heat conduction mechanism. The same mechanism explains generation of a dense low-temperature plasma by h-f discharge in a static gas at atmospheric pressure, or in a gas flow through an induction plasma torch, "flame" propagation in atmospheric air in s.h.f. waveguides, s.h.f. discharge in a gas flow in plasmatrons of different geometry, or in a Kapitsa resonator, as well as arc discharge in a plasmatron in the absence of gas flow.

Temperature determination and h.f. or s.h.f. discharge stabilization are discussed for the cited configurations. One chapter is devoted to stabilization of an optical discharge in an optical plasmatron by laser beam focusing, a subject frequently reported on by Rayzer. A nonequilibrium ionization wave regime is established in a pulsed discharge in stationary inert gases with a cesium vapor admixture, owing to electron thermal conductivity. The well-known static discharge contraction in a d.c. field is variously explained by radiation or heat transfer to the wall. The ionization wave in a shock wave or spark-induced, localized inert gas plasma in a s.h.f. waveguide propagates by the mechanism of resonance radiation transfer. In contrast, the ionization wave initiated by s.h.f. discharge in a molecular gas (N_2, air) propagates by a thermal conduction mechanism. Another possible mechanism of optical-discharge-induced wave propagation is the superdetonation heat conduction regime which prevails at a beam intensity higher than that which initiates supersonic detonation. Plasma temperature in this case attains several million degrees and the discharge wave propagates with a velocity higher than the shock wave velocity. This regime is analogous to the heat wave generated at an early stage of very strong explosions.

Finally, the radiation mechanism is discussed in relation to propagation of a laser spark from giant pulses. The breakdown wave initiated by a focused laser beam with intensity above the breakdown threshold propagates at "phase" velocities by a mechanism basically different from all cited mechanisms.

Galeyev, A. A., G. Laval', T. O. Neyl, M. N. Rozenblyum and R. Z. Sagdeyev. Inverse parametric scattering of a nonlinear electromagnetic wave in plasma. ZhETF, v. 17, no. 1, 1973, 48-52.

The authors consider two parametric instability processes responsible for the conversion of incident electromagnetic wave energy into the energy of plasma oscillation, namely, decays of photon (pumping wave) → plasmon + phonon (ionic sound), and photon → plasma + plasmon. The first of these processes takes place in a specific layer of the corona where the frequency of an incident e-m wave is approximately equal to plasmon electron frequency ($\omega_o = \omega_s$) while the second process takes place when plasma density $n = n_c/4$ where n_c is critical density. In addition, parametric instability is possible when the energy of a pumping wave is converted into scattered e-m radiation. This involves two types of decay: photon → photon + plasmon, and photon → photon + phonon. These processes can take place and in the outer part of a corona where density $n << n_c/4$, and can be serious if the incident e-m wave will be scattered before reaching the region where $n = n_c/4$.

The question is then considered as to whether the scattered e-m starting from an initial level of thermal noise, and propagating in the homogeneous plasma corona, can be amplified. Since the process of inverse parametric scattering is complex, an approximate quasilinear analytical model of the processes in the form of a third-order ordinary differential equation is used. The solution of this equation is obtained, on the basis of which the instability increments and amplification factors for 90^o scattering are established. It is concluded that the pumping wave almost entirely converts into scattered e-m radiation and the incident flow of energy rapidly decreases inside the corona. It is emphasized that the model used in applicable only for a limited intensity of incident radiation; for higher intensities, the parametric scattering phenomena change and require a different attack.

Lisitsa, M. P., and I. V. Fekeshgazi. Laser irradiation damage on the surface or within transparent glass. IN: Sb. Kvantovaya elektronika, no. 5(11), 1972, 81-88.

This is an extension of studies by the authors on pulsed laser damage to various transparent dielectrics (cf. February 1972 Report, pp. 2, 3). In the present case type K-8, LK-5 and TF-5 glass specimens were exposed to 15-40 ns ruby laser pulses over a medium focal range ($3<f<8$cm), and at pulse energies varying from threshold up to 1.2 j, or about 15 times threshold. Results are treated for the three general cases of input surface damage, internal damage, and exit face damage. Crater geometry, filament formation and crack propagation data are given for all cases and compared. Residual stress patterns were also observed under polarized light.

Figs. 1 and 2 show effects for internal and exit face damage,

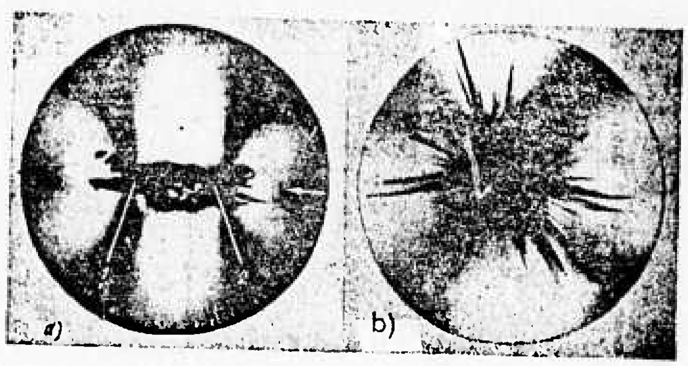

Fig. 1. Internal breakdown in glass (x 16.8)
a- along beam axis; b- normal to beam.

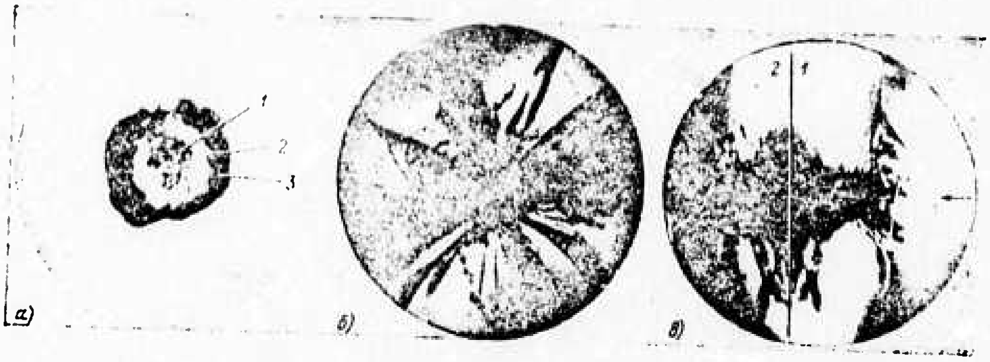

Fig. 2. Exit face damage.

a- crater from low-intensity pulses, (x36); b, c- in polarized light, high-intensity pulse (x 16.8); in (c), 1 denotes specimen, 2 its image- arrow is laser beam direction

respectively. Although different for the three types of glass, the damage effects were qualitatively the same, hence the results are typical for all specimens.

Gurevich, G. L., and V. A. Murav'yev. Effect of laser irradiation on thin films. FiKhOM, no. 1, 1973, 3-8.

A theoretical solution is presented to the problem of heating thin metallic or semiconductor films by a laser beam, focused on a small (1-10 μ) area of the film surface. The problem arises in preparation of film elements, e.g., holes or bands, of a few microns in size for microelectronic devices.

A general formula is obtained for heat transfer at the film-dielectric substrate boundary; this is applicable to the most frequently used films of thickness $h = 10^{-5}$ cm. heated by a focused laser beam with $\lambda \geq 0.3 \times 10^{-4}$ cm. With the cited formula an analysis was made of film heating by a c-w laser beam (stationary case) and a free-running pulsed laser (nonstationary case). Threshold power density for film

breakdown was determined to be 30% higher in the nonstationary case. The authors conclude that during the initial heating period of $\sim 10^{-8}$ - 10^{-6} sec, surface gradients of T(0, t) attain stationary values; during the following period of $\sim 10^{-2}$ sec, T attains its stationary value in all points at the same rate.

Andreyev, V. G., and P. I. Ulyakov. <u>Thermoelastic stresses in a plate from a cylindrical source with an arbitrary time-intensity characteristic</u>. FiKhOM, no. 1, 1973, 27-31.

An analytical solution is obtained to the three-dimensional quasistatic problem of thermal elasticity in a plate, heated by a cylindrical (beam) source with arbitrary time vs. intensity f(t) and exponential optical depth kz vs. intensity dependencies. It is shown that in the particular case of optical thickness $kH \leq 1$ or $kH \to \infty$ and $f(t) = 1$, the solution for T(r, t) coincides with known solutions previously obtained by the authors (I-FZh, v. 15, no. 6, 1968) for a source with a constant kz vs. intensity characteristic, or by different authors for a beam source with a constant time-intensity characteristic. The components $\sigma'_{\varphi\varphi}$ and $\sigma''_{\varphi\varphi}$ of thermoelastic stresses σ'_{ik} and σ''_{ik} which correspond to the solution obtained for T(r, z, t) are formulated as functions of the thermoelastic displacement potential $\Phi(r, z, t)$ and the deformation potential $\varphi(r, z, t)$.

Computation of $\sigma_{\varphi\varphi}$ on the face z = 0 of a glass plate ($k = 12\ cm^{-1}$) shows that tensile $\sigma_{\varphi\varphi}$ reaches the tensile limit of the material long before its softening, and causes glass breakdown within several tens of μsec from the start of heating. In optically thin plates, i.e., with a small kH, the deviation of the $\sigma_{\varphi\varphi}$ values thus calculated from the plane elastic state is estimated to be small, e.g., 0.6% for H = 1 cm and $k = 0.006\ cm^{-1}$, and is basically dependent on kH.

Aliyev, Yu. M., O. M. Gradov, and A. Yu. Kiriy. Anomalous dissipation and penetration of strong electromagnetic radiation into a confinded plasma. ZhETF P, v. 17, no. 3, 1973, 177-179.

Stationary penetration is analyzed of a transverse electromagnetic wave into a semi-confined plasma ($z > 0$) with allowance for external energy (S^{tr}) conversion into energy (S^{l}) of longitudinal, plasma and acoustoionic noise parametrically interacting in a nonhomogeneous pumping field. Transverse wave incidence is assumed to be normal and its frequency ω_o close to ω_p of the plasma. Parametric interaction between noise types is localized near the boundary. The $S^{tr} \rightarrow S^{l}$ conversion occurs outside the interaction region where increasing longitudinal noise decreases the amplitude $E_o(z)$ of a transverse wave. The depth of pumping wave penetration decreases according to the formula

$$L = \frac{1}{2\kappa} \ln(S^{tr}/S^{l}), \quad S^{tr} > S^{l} \tag{1}$$

where k is the maximum value of k_z'', the incremental rise of acoustoionic and plasma waves. The formula for k is derived by solving a dispersion equation for k_z.

In a laser-heated plasma collision frequency ν_{eff} corresponding to L of (1) is estimated to be significantly higher than the usual ν_{ei}. In the example given for H plasma with ne = $10^{21}/cm^3$ and T_e = 16 keV, heated by a Nd glass laser at $\omega_o = 1.78 \times 10^{15}$ sec^{-1} and $E_o \leq 6.10^8$ V/cm, we thus have

$$\nu_{эфф}/\nu_{ei} \approx 5 \cdot 10^{-6} E_o \tag{2}$$

B. Recent Selections

i. Beam-Target Effects

Abrikosova, I. I., and B. V. Anshukov. Role of laser self-focusing in breakdown of liquid He^4. ZhETF, v. 64, no. 4, 1973, 1141-1145.

Anisimov, S. I., and B. I. Makshantsev. Role of absorptive nonuniformities in optical breakdown of transparent materials. FTT, no. 4, 1973, 1091-1095.

Bergel'son, V. I., and I. V. Nemchinov. Plane self-similar motion of a radiation-heated gas with strong re-radiation. PMM, v. 37, 1973, 236-242.

Karyakin, A. V., A. M. Pchelintsev, A. I. Shidlovskiy, Ye. K. Vul'fson, and M. N. Tsingarelli. Possible laser application in atomic absorption analysis of geochemical objects. ZhPS, v. 18, no. 4, 1973, 610-613.

Novikov, N. P. Damage mechanism of plexiglass-type transparent dielectrics from laser radiation. MP, no. 2, 1973, 232-238.

Petrov, S. Ya., and B. D. Faynberg. Absorption analysis of strongly-absorptive substances. OiS, v. 34, no. 4, 1973, 815-817.

ii. Beam-Plasma Interaction

Alimov, D. T., N. K. Berezhetskaya, G. A. Delone, and N. B. Delone. Frequency dependence of multiphoton ionization processes of noble gas atoms. ZhETF, v. 64, no. 4, 1973, 1178-1183.

Aliyev, Yu. M., O. M. Gradov, and A. Yu. Kiriy. Exciting ion-acoustic oscillations in a dense plasma by means of powerful e-m radiation. IN: Sbornik. VI Vsesoyuznaya konferentsiya po nelineynoy optike, Minsk, 1972, 226 p. (RZhElektron, 4/73, no. 4A308)

Barchukov, A. I., F. V. Bunkin, V. I. Konov, and A. M. Prokhorov. Low-threshold air breakdown near a target under CO_2 laser radiation, and the associated strong recoil pulse. ZhETF P, v. 17, no. 8, 1973, 413-416.

Burakov, V. S. Inertness criteria of a plasma to powerful laser radiation. ZhPS, v. 18, no. 4, 1973, 604-609.

Frolov, V. A., and P. A. Tarasov. Spark discharger with an electrical or optical trigger. PTE, no. 2, 1973, 110-111.

Kaliski, S. Numerical analysis of the averaged equations of concentric laser cumulation of plasma with consideration of nuclear fusion energy. Bulletin de l'Academie Polonaise des Sciences, serie des sciences techniques, no. 3, 1973, 29(221)-34(226).

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Pustovalov, V. K. Radiation heating of a two-temperature plasma, taking electron thermal conductivity into account. Self-similar solution. DAN BSSR, no. 4, 1973, 313-315.

Razdobreyev, A. A., and V. I. Bukatyy. Laser method for studying ignition and combustion of metal particles. IVUZ Fiz, no. 4, 1973, 155-157.

2. Effects of Strong Explosions

A. Abstracts

Voytenko, A. Ye., M. A. Lyubimova, and Ye. P. Matochkin. An explosive shock tube. TVT, no. 6, 1972, 1280-1284.

Experiments with a small size model of an explosive shock tube are described. The experimental unit and an x, t-gas flow diagram are shown in Fig. 1. The compression chamber volume is

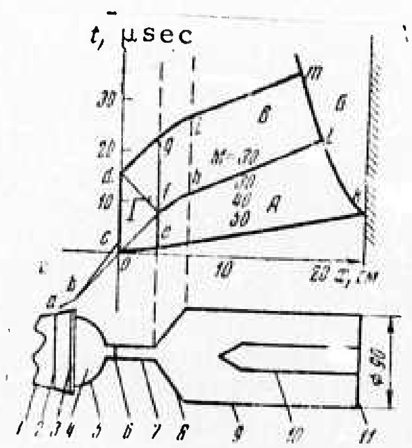

Fig. 1. Experimental unit and x, t-flow diagram

1- 0.5 kg of trotyl (50%) RDX (50%) compound; 2- detonation wave front; 3- metal plate; 4- working gas; 5- compression chamber; 6- diaphragm; 7- tube; 8- cone; 9- transparent cylindrical chamber; 10- flow model; 11- chamber bottom.

100 cm^3 and is filled with air under normal conditions. After an explosion, high pressure and high temperature are obtained, causing the rupture of diaphragm 6 resulting in a high-velocity gas flow in chamber 9. Photographs of the flow past a sphere and a pointed rod are included. An analysis of the photographs is made and from the measurement of Mach cone angle a variation of Mach number from 3 to 5 was established. Since

the flow is nonstationary, the simplified flow may be represented as in Fig. 1. It is explained how flow parameters in particular portions were determined. The experimental values of flow parameters presented are in good agreement with results obtained by other authors.

Batsanov, S. S., and E. M. Moroz. X-ray analysis of residual stresses in shock-compressed crystals. FiKhOM, no. 6, 1972, 127-129.

The results and methods of an x-ray analysis of CaF_2, CdF_2, BN, and CuBr shock-compressed test samples are presented. It is noted that shock hardening of the samples occurs automatically because of the rapid drop of temperature due to instantaneous action of the shock load. Under such conditions residual stresses were detected in shock-compressed crystals on the basis of interference line shift observed by the x-ray method.

For CaF_2 and CdF_2 specimens compressed by explosion of 400-500 g hexagene, variations in strain parameters were measured, accurate to ± 0.0005 Å. For CaF_2 this variation was from 5.4620 Å to 5.4592Å, and for CdF_2 - from 5.3839 to 5.3819 Å. It is emphasized that with decrease in strain an increase in crystal density and dialectric permeability is observed. Analyzing the phase transition in BN, the authors observed oriented residual stresses in the direction of the c-axis of a hexagonal lattice, due to the reduction of parameter c from 6.66 Å to 6.56 Å. Residual stresses were also detected in a $CuBr_2$ + Cu system, when owing to shock compression monovalent CuBr is formed. The maximal parametric change was observed (from 5.643 Å to 5.690 Å) when a test specimen was twice compressed by 150 gr RDX charges in a standard cylindrical container.

Antonov, Ye. A., L. N. Gnatyuk, B. M. Stepanov, Yu. I. Filenko and V. Ya. Tsarfin. Holographic study of electric explosion of wires. TVT, no. 6, 1972, 1210-1213.

Experiments with holographic recording of various stages of wire explosion in air and water are described. The wire explosion stages simultaneously were photographed as shown in Fig. 1. Two types of

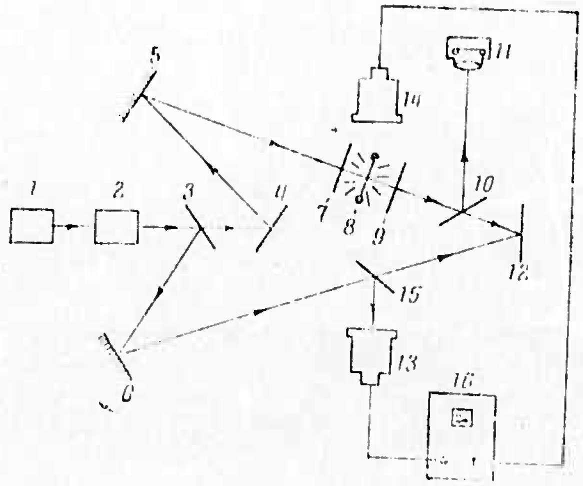

Fig. 1. Exploding wire.

1 - ruby laser; 2 - optics; 3, 10, 15 - splitters; 4, 5, 6 - reflectors; 7 - scatterer; 8 - wire specimen; 9 - filter; 11 - camera; 12 - holographic recorder; 13, 14 - photoelements; 16 - oscillograph.

explosions were considered: 1) when the electric energy applied to the wire is sufficient for explosion but not enough for its complete evaporation; and 2) when the energy supplied to the wire is sufficient for wire evaporation. Photos taken with the holographic equipment for various stages of two types

of wire explosion in air are included. Fig. 2 presents the photograph

Fig. 2. Reconstructed image of wire exploding in water.

of wire explosion in water. An analysis of the photographs is given and the energies necessary for wire explosion are estimated. Also, estimates for the velocity of wire fragments, the shock wave velocity and the concentration of electrons in the plasma are presented. The advantage of holography for recording wire explosions as compared with the ordinary photographic method is stressed.

Bagdoyev, A. G., and Z. N Danoyan.
Study of motion of a medium near a shock wave contact point using linear and nonlinear formulation. ZhVMMF, no. 6, 1972, 1512-1529.

Motion parameters u_i of a fluid medium near the point or line of contact between a weak shock wave and the diffracted wave are determined theoretically in linear and nonlinear approximations. In the two-dimensional problem, the contact is represented by the point B (Fig. 1); in the three-dimensional problem it is the line B (Fig. 2)

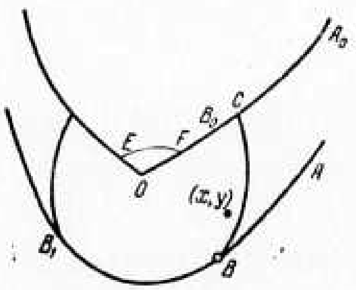

Fig. 1. Two-dimensional problem of shock wave AB reflection from surfaces intersecting at an angle with a vertex in O, e.g., a wedge: A_0B_0O - initial position of AB, BB_1 - diffracted shock, EF - hypersphere.

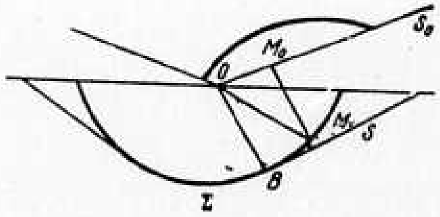

Fig. 2. Three-dimensional problem of shock wave S reflection: S_0 initial wave, Σ - diffracted shock.

In the first approximation, the fluid medium is described by a set of quasilinear differential hyperbolic equations. To obtain a linear solution for u_i, this set is reduced to a set of linear hyperbolic equations

$$L(u_i) = 0, \qquad L(u_i) = a_{ij}^{(k)} \frac{\partial u_j}{\partial x_k} + K_{ij} u_j \qquad (1),$$

where L (u_j) is a linear operator, a_{ij} are the matrix elements x_k is the radius vector of a point in an (n + 1) dimensional space. Equations (1) are solved for u_j in two steps. In the first step, a set of linear differential equations in three ($x_1 = t$, $x_2 = x$, $x_3 = y$) or four (t, x, y, $x_4 = z$) independent variables with constant $a_{ij}^{(k)}$ is substituted for (1) and solved for $u = u_j$ using an integral Fourier transform. In the second step, this solution is extended, using the Green function, to Eqs. (1) with variable $a_{ij}^{(k)}$ and final solutions are derived for u_j, a_i, and u^o near the point or line B (a_i is a given vector determined from the boundary condition at O).

The linear solution to the three-dimensional problem can be applied to the problem of a plane wave diffraction at the vertices of a polyhedral angle. A simplified nonlinear solution to the two-dimensional problem is obtained by two methods, incorporating MHD concepts, which are also described. The nonlinear equations formulated by both methods are solved for shock wave velocity. They are further simplified for magnetohydrodynamic waves. Analogous methods were used to derive nonlinear equations for solution of three-dimensional problems.

Tarasov, B. A. Time dependence of plexiglass strength under shock loads. Problemy prochnosti, no. 12, 1972, 63-64.

Experiments have shown that between time τ to material fracture and the corresponding applied stress δ, there exists the relationship

$$\tau = Ae^{-a\sigma}, \tag{1}$$

where A and a are constants; this is valid for $\tau \geq 10^{-3}$ sec. The author thus

investigates $x(\delta)$ when the application of the load is instantantenous, as in an impact load or explosion. An experimental study of this problem is described, using three pairs of plexiglass discs of 50 mm diameter and with the following thicknesses: 1-2 mm, 2-4 mm, and 2.8-7 mm. The plates were impacted along the plane surfaces. For each pair of plates the impact velocity at which the fracture of plates occurred was recorded. Two types of fractures were observed: isolated fracture pockets and total fracture of the surface. The experimental results are presented in two tables and a graph showing the τ - δ relationship.

Soloukhin, R. I. <u>Kinetics of N_2O thermal decomposition in shock waves.</u> DAN SSSR, v. 207, no. 4 1973, 912-915.

Shock tube experiments are described in which $[N_2O]$ was measured behind the propagating and reflected shock waves in 1.5-5% N_2O mixtures with argon and in pure N_2O. The experimental induction periods $\tau[M]$ of the N_2O thermal decomposition in the mixtures at different temperatures T indicated that the controlling reaction is monomolecular. The initial phase of decomposition can be described by the reactions:

$$N_2O + M \xrightarrow{1} N_2 + O + M,$$
$$k_1 = 4.7 \cdot 10^{\text{[illegible]}} \exp(-58000/RT) \text{ cu. cm/mol x sec}$$
$$O + N_2O \xrightarrow{2,3} N_2 + O_2 \text{ (or } 2NO),$$
$$k_2 \text{ [illegible] } k_3 = 4.5 \cdot 10^{\text{[illegible]}} \exp(-24100/RT). \quad (1)$$

Kinetic studies of (1) show that $\tau[M]$ in undiluted N_2O is controlled by a quasistationary [0] approximation, i.e., by N_2O dissociation. In contrast, [0] in highly diluted N_2O increases linearly in the initial decomposition phase and the effective rate constant of N_2O decomposition at the end of the induction period is given by:

$$k' = d\log(N_2O)/dt = -k_1[M](1 + 2\,\delta\alpha\beta)^{\frac{1}{2}} \qquad (2),$$

where $\alpha = k_2 + k_3/k_1$, $\beta = [N_2O]_0/M$, and δ is the depth of N_2O decomposition. It follows from (2) that the effective activation energy of N_2O decomposition is 58 and 41 kcal/mol at a high and a relatively low T, respectively. The data thus obtained explain the apparent discrepancies in earlier activation energy data, and confirm the monomolecular nature of N_2O conversion.

Zaslonko, I. S., S. M. Kogarkov, Ye. V. Mozzhukhin, and Yu. P. Petrov. Thermal decomposition of nitromethane in shock waves. KiK, v. 13, no. 5, 1972, 1113-1118.

High-temperature decomposition of CH_3NO_2 was studied by measuring rate constants of the C-N bond breaking and secondary radical reactions. The experiments were carried out in a shock tube at 1,030 - 1,580° K and 1-2.8 atm pressure in both incident and reflected shock waves. Absorption and emission spectra of the reacting gas were recorded in the 2,200-3,500 Å spectral range at specific times after advent of a shock wave. CH_3NO_2 consumption and NO_2 formation were monitored by simultaneously recording absorption at 2,390 and 4,350 Å and emission at 4,050 Å. Oscilloscope traces of absorption and emission are shown,

and CH_3NO_2 concentrations and rate constants k_1 of the reaction

$$CH_3NO_2 \rightarrow CH_3 + NO_2 \tag{1}$$

are tabulated. Qualitative analysis of the absorption and emission spectra reveals that the initial phase of CH_3NO_2 decomposition is preceded by the mechanism of (1) followed by the fast free-radical reactions

$$CH_3 + NO_2 \rightarrow CH_3O + NO \tag{2}$$
$$CH_3 + NO_2 \rightarrow CH_3ONO \tag{3}$$

The formation of a CH_3O radical was detected by chemiluminescence of the electronically excited H_2CO molecules. The rate constant of (1) obeys the empirical equation $k_1 = 10^{12.8} \exp(-48,100/RT) \mathrm{sec}^{01}$, which confirms the CH_3NO_2 decomposition mechanism established by Cottrell and later researchers. Comparison of the k_1 data obtained by the authors and data from the literature (Fig. 1). shows a dependence of the CH_3NO_2 decomposition

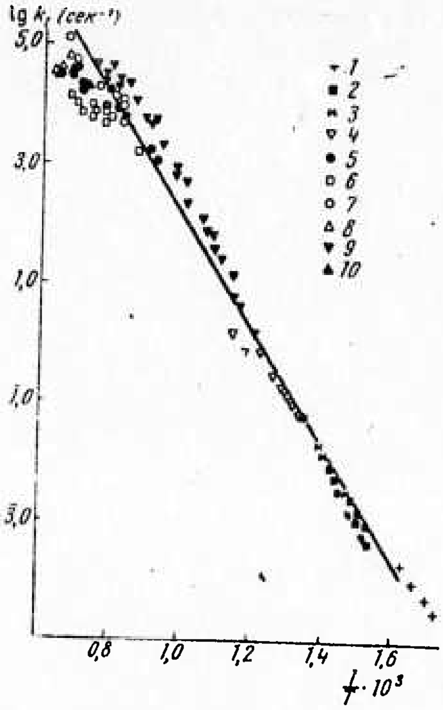

Fig. 1. Rate constants of CH_3NO_2 decomposition versus temperature: 1, 2, 3, 4, 6, 9- literature data, 5, 7, 8, 10- authors' data.

rate at T > 1200° K and P<2 atm on the activation rate of CH_3NO_2. The authors' conclude that discrepancies in the experimental high-temperature k_1 data of different authors are due to the pressure-dependence of k_1. The experimental data suggest that, within the time limits of constant k_1, the reactions (1) and (2) mainly occur. The rate constant k_2 of the reaction (2) in the 1360-1500° K range was $\sim 2.5 \times 10^9$ ℓ/mol. sec, and practically independent of temperature.

Kassel'man, P. M., Yu. P. Zemlyanykh and Ye. S. Yakub. Determining the coefficient of thermal conductivity of diatomic gases in a shock tube. TVT, no. 5, 1972, 1018-1024.

An attempt is made to revise well-known experimental methods for determining heat conductivity of a monatomic gas using a shock tube, so that this data could be applied to the study of diatomic gases at high temperatures. The methods were revised such that they could be applied to the shock tube described by Zemlyanykh (IAN BSSR, Seriya fiz-energ. nauk, no. 2, 103, 1970).

It is assumed that the shock wave formed after rupturing the diaphragm reflects from the end of the tube, leaving behind a high-temperature gas. To describe the heat transfer process from the heated gas to the wall of the tube, it is assumed that the problem is one-dimensional; the pressure is constant behind the reflected wave; and radiation from the heated gas is negligible. For the description of the relaxation process, the following added assumptions were made: rotational and translational degrees of freedom are in equilibrium; due to intensive resonance heat exhange, the oscillatory degrees of freedom are in a local thermodynamic equilibrium and under isothermic conditions the

process is described by the Landau-Teller theory. Heat conduction equation and gas relaxation equations in Landau-Teller form are derived. The solution of the system of these two equations is sought in the domain between the end of the tube and the front of the reflected wave. Corresponding boundary and initial conditions are established.

By introducing variables the system is reduced to a form which was solved by a finite-difference method on a Minsk-22 computer for various Mach numbers of the incident shock wave. Numerical results were obtained for non-dissociated nitrogen in the temperature range 1000° K < T $\leq 6000^{\circ}$ K for pressure p = 1 atm. The obtained results are analyzed and presented graphically. The authors conclude that the method proposed can be used for determining heat conduction of other diatomic and polyatomic gases.

K lgan, V. P. and A. S. Fonarev. Flow pattern during shock wave incidence on a cylinder or a sphere. MZhiG, no. 5, 1972, 97-103.

The problem of diffraction of a shock wave by a fixed cylinder or sphere is analyzed. The gas dynamics equations, under the assumption that viscosity and heat conductivity are neglected, are presented with initial conditions established ahead of and behind the shock wave. The method developed by Godunov (Matem. sb. 1959, v. 47, no. 3 and ZhVMMF, 1961, v. 1, no. 6) is applied to the solution of the system of equations. The authors describe the successive stages of diffraction of a shock wave and various flow patterns as a function of Mach number.

The described diffraction pattern can be verified by numerical solutions of the cited system of equations. Some calculated results of shock wave diffraction and of steady subsonic, transonic and supersonic flow around a sphere and cylinder are presented; curves of equal pressures at various instants of time are graphically represented for all three cases. For various values of Mach number, the total dimensionless force f(t) acting upon the sphere and cylinder is calculated. The calculated action of the shock wave with $M_{\infty} = 0.2p$ upon the cylinder is compared with experimental data. The obtained results were compared with numerical solutions of stationary flows around the bodies.

Chekalin, E. K., V. S. Shumanov, and Ye. P. Afinogenov. Ionized metal vapor flow interactions with a body at $M \geq 1$. IN: Sbornik. Teplofizicheskiye svoystva i gazodinamika vysokotemperaturnykh sred. Moskva, Izd-vo Nauka, 1972, 96-106. (RZhMekh, 1/73, no. 1B66) (Translation)

Results are described of experimental investigations on sonic and supersonic flow of ionized copper and lithium vapors. Contact methods are outlined of flow parameter measurements. Flow velocity, Mach number, temperature, density and the pressure of erosion plasma flux, formed during electrical wire explosion and electrode erosion, were determined by means of two plane calorimeters, a ballistic pendulum, hypersonic photography and emf induced in the magnetic field. The results were varified by other methods, e.g. according to Stark broadening of the H_{β} line.

Vorob'yev, N. F., and V. P. Fedosov. <u>Supersonic flow around a dihedral angle. (Conical case).</u> MZhiG, no. 5, 1972, 170-175.

Supersonic flow past intersecting plane wings forming a dihedral angle $\pi \leq \gamma \leq 2\pi$ is analyzed using linear flow theory. It is assumed that the velocity vector of the incident wave forms a small angle with the sides of the dihedral angle, so that disturbances introduced by the sides are small. The motion in the disturbed region is assumed to be vortex-free and the gas to be viscous and thermally non-conducting.

The linearized system of gas dynamics equations is reduced to a wave equation for the pressure function, with the form

$$(M_\infty^2 - 1) p_{xx} - p_{yy} - p_{zz} = 0 \tag{1}$$

This equation is given the Laplace transform; the pressure function p, which is the real part of a certain $f(\sigma) = (p + is)$ function of a complex variable σ, is then sought. The domain in which $f(\sigma)$ is defined is indicated and boundary conditions formulated. The domain of definition of $f(\sigma)$ is conformally mapped in the upper half-plane and the problem of determining p is reduced to the Hilbert problem for the upper half-plane.

The general form of the solution is presented and the values of pressure p on the edge and the sides of the dihedral angle are established. The effect of the nonlinearity of boundary conditions (for the case of diffraction of the leading characteristic surface) on the flow parameters in the vicinity of the dihedral angle, edge, is analysed. On the assumption that variation of the shock wave intensity in the diffraction region is linear, the authors then derive expressions for pressure on the sides of the dihedral angle as well. Some graphical results are included.

Golovachev, Yu. P., and F. D. Popov. Supersonic viscous gas flow around a cooled blunt sphere. ZhPMTF, no. 5, 1972, 135-143.

Supersonic viscous gas flow around a blunt sphere is analyzed on the basis of flow equations obtained from complete Navier-Stokes equations, disregarding terms of order $0(R^{-\frac{1}{2}})$, $0(R^{-1})$ etc. (R - Reynolds number) over the entire shock layer. The general forms of these equations in spherical coordinates are derived for the axially symmetric nonstationary case, and the necessary boundary conditions are established. New three-dimensional variables are introduced and the initial system of equations is written in matrix form. This system is substituted by a system of difference equations, utilizing an implicit scheme. The boundary value problem for such a system of nonlinear difference equations is solved by the method of successive approximations.

Calculations were done for supersonic flow around the sphere by a perfect gas with specific heat ratio $\gamma = 1.4$ and Reynolds numbers $10^2 \leq R_\infty \leq 10^5$. The temperature factor k was taken within the range 0.14 - 0.7 and it was assumed that the coefficient of dynamic viscosity is a power function of time with exponent ω. In most of the calculations $\omega = \frac{1}{2}$ and Prandtl number $P_\infty = 0.7$ were taken. Various relations between flow characteristics are represented in graphical form.

Calculated results were compared with known solutions of the complete Navier-Stokes equations, with the results obtained by the theory of nonviscous flow and boundary layer, as well as with experimental data. Comparison of the results shows that the simplified flow equation can be used for Reynolds numbers $R_\infty \geq 10^2$.

Rusanov, V. V. Structure of the transonic region during supersonic axisymmetric flow around blunt bodies. IN: Sbornik. XIII Mezhdunarodnyy kongress po teoreticheskoy i prikladnoy mekhanike, 1972. Sbornik annotatsiy. Moskva, Izd-vo Nauka, 1972, 94-95. 9RZhMekh, 1/73, no. 1B236) (Translation)

This work considers axisymmetric flow around blunt bodies with generatrix described by the equation in cylindrical co-ordinates $r^2 = 2z + az^2$. Structural relationships were investigated of the transonic region, restricted by critical characteristics from parameter q and Mach number M_∞ of incident flow. Boundaries were found in the plane of parameters M_∞, q of regions, in each of which one of the four types of flows was realized, which were different in behavior of sonic lines near the body surface. In type II and III flows, the sonic line intersects the body surface at a certain point, but in case of type IV and V flows it does not reach the surface and the subsonic region extends to infinity.

Biberman, L. M., S. Ya. Bronin and A. N. Lagarkov. Radiative-convective heat transfer in hypersonic heat flow around a blunt body. MZhiG, no. 5, 1972, 112-123.

Hypersonic flow of air around a blunt body near its critical point is analyzed, under the condition that gas parameters at the shock wave front are subject to stepwise changes and that the gas in the shock layer is in a state of local thermodynamic equilibrium. Ablation of the heat reflecting cover is not taken into account. A system of five gas dynamic equations, together with the radiation transfer equation given in integral form, were solved by iteration; the procedure as well as the methods for increasing its convergence were described in detail earlier by the same authors (Novosibirsk, 1969, Izd-vo Vychislitel'nogo Tsentra ANSSSR, 1972). Numerical solutions of the system made it possible to determine the value

of shock wave travel as well as the velocity, pressure and temperature profiles of the convection and radiation flows in the vicinity of the critical point.

On the basis of the study it was concluded that radiation transfer does not change the pressure in a compressed layer, but substantially decreases temperature and increases density. Approximate simple relations for heat flow parameters in the vicinity of a critical point are derived; some of these relations have the form of similarity laws. It is pointed out that substantial difficulties arise when the heat conduction problem is analyzed in points remote from critical ones, i. e, the system of gas dynamics equation becomes more complicated. Nevertheless, the proposed approximate theory of radiative transfer and other obtained results in this article can be useful in solution of the more complicated case.

Bogdanov, P. A., A. V. Nedzvetskiy, A. V. Klevetenko, P. S. Malyy, A. S. Kolodeznev, N. I. Bushchuk, and F. I. Shmeretskiy. Evaluating the strength of rock massifs during large-scale blasting. IN: Sbornik. Gornorudnoye proizvodstvo. Krivoy Rog, 1972, 51-53. (RZhMekh, 1/73, no. 1B655) (Translation)

Initial relationships are outlined for determining the strength of rock massifs during large-scale blasting. The critical displacement velocities are cited which were obtained during mining tests, and a relationship is found for determining particle displacement velocity of massifs as a function of a given weight of explosives. The occurrence frequency of destructive sound in rock massifs was noted to fluctuate during explosion.

Puchkov, S. V. Behavior of uniform seismic resistance dam configurations under the effect of short-duration seismic loads. IN: Sbornik. Voprosy mekhaniki, Tashkent, Izd-vo Fan, no. 11, 1972, 59-63. (RZhMekh, 1/73, no. 1V771). (Translation)

The behavior of uniform seismic resistance dam configurations is investigated under the effect of short-duration seismic loads. Expressions are obtained for determining displacements in the dam body.

Repin, N. Ya., and A. V. Biryukov. Calculating the degree of rock crushing from explosion of borehole charges. IVUZ Gorn, no. 10, 1972, 75-78.

For rock explosions it is pointed out that in calculating the diameter of an average fragment using a weighted-mean formula, it is necessary to establish experimentally the volume of fragments. This is laborious, in addition to which the calculated results depend on the number of fragments. These difficulties can be eliminated by determining the relation between the weighted mean d and the arithmetic mean u of the fragment diameter. The diameter of the fragment is considered as a random variable. Based on the authors' previous findings establishing that the diameter of the rock fragment, as a random variable, obeys a gamma distribution, the following relationship is derived:

$$d = M(u)\frac{p+3}{p}. \qquad (1)$$

where M(u) is a mathematical expectation of fragment diameter and p is a distribution parameter. For a large sample (150-200 measurements in the studied case) the mean-arithmetic diameter of a fragment can be considered as equal to the mathematical expectation of a diameter, i.e. u = M(u). It is also shown that the relation between the diameter d_p of the mean fragment the diameter d_e of the mean jointing (polyhedral block) and the specific expenditure q of explosives is given by

$$d_p = \frac{d_e}{1 + \frac{10(H - l)}{d_з} q d_e}. \tag{2}$$

where H is the height of the base, ℓ is the break length and d_z is charge diameter. Comparison of actual and calculated values of the diameter of a mean fragment indicates that their values deviate by not more than 15%. From Eq. (2) the value q can be calculated, which ensures the prescribed fragmentation degree for given parameters of the rock formation.

Mindeli, E. O., and A. S. Volokh. Calculating blast wave parameters in rocks. IN: Sbornik. Gornorudnoy proizvodstvo, Krivoy Rog, 1972, 136-139. (RZhMekh, 1/73, no. 1V653) (Translation)

Fundamental equations and methods of their transformation for computers are outlined for determining energetic parameters of media. during explosive loading. The suggested method is verified and the obtained results are in good agreement with experiment.

Baldins'kiy, V. L., V. P. Kuksa, and V. F. Barannikov. Impact destruction of solid materials. IN: Sbornik. Nauka i tekhn. v mis'k. gosped, no. 20, 1972, 35-42. (RZhMekh, 1/73, no. 1V638). (Translation)

Various parameters are determined of an impact destruction process, i.e. initial velocity and impact force, deformation value of the soil, and work and power of deformation. A method is suggested for determining the main parameters during interaction of a shock device with a solid material.

Umanskiy, A. S. Transfer coefficients, second virial coefficients, and energy of atom-atom interactions of Zn, Cd and Hg vapors. ZhFKh, no. 11, 1972, 2706-2709.

Dynamic viscosity η, coefficient of thermal conductivity λ, and second virial coefficient B of Hg, Zn, and Cd vapors were calculated in the 360-2,700° K, 350-2,630° K, and 410-3,065°K ranges, respectively. Standard formulas, including the Chapman-Enskog approximation, and the parameters ϵ, r_m, and α from the modified Buckingham intermolecular potential (exp-6) were used in the calculations. The parameters were determined from formulas established previously by the author (TVT, v. 8, no. 6, 1970, 1292) for inert gases, and modified by introducing additional terms which account for the effect of the valence electrons in the outer unfilled shell of the group IIB elements. The calculated η and B data for Hg, which are tabulated and plotted against T, effectively coincide with data from the literature. The fact that the intermolecular separation r_m

between two hydrogen atoms, which was calculated from the modified r_m formula, is in satisfactory agreement with the minimum H-H interaction energy in the triplet state was taken as an indirect proof of the reliability of the η, λ, and B data thus calculated. The possibility is also discussed of using Lennard-Jones (α-6) and (exp-exp) type potentials in calculations of the macroscopic properties of group IIB metal vapors.

Altunin, V. V. and M. A. Sakhabetdinov. Application of orthogonal expansions for computer generation of a unified equation of state for materials, based on diversified experimental data. TVT, no. 6, 1972, 1195-1202.

The authors explain a statistical approach to formation of a thermal equation on the basis of thermodynamic experimental data. In the most general formulation the problem of constructing the thermal equation reduces to estimation of the parameter A in the relation $F(p, v, T, A) = 0$ on the basis of processing of various experimental thermodynamic properties.

The authors propose two methods for solution: the method of least squares where regular polynomials are used, and the method of orthogonal polynomials. The authors assert that the method of orthogonal polynomials is simpler than the least-squares method, since the rounding errors are smaller; it economizes on computer time, and is very simple for statistical analysis. The authors analyze characteristics of thermal equation formation using the method of orthogonal polynomials for an arbitrary set of experimental thermodynamic points. The ordered sequence

of orthogonal polynomials was derived by applying the Shmidt-Gramm orthogonalization process to the set of ordered thermophysical properties. This formed the basis for compiling a program for approximation of various surfaces by orthogonal polynomials, which was realized as a routine for BESM-4 computer. A generalization of the method of orthogonal polynomials to processing of diversified experimental data under certain thermodynamic constraints is made.

Koshelev, E. A. and Ye. N. Sher. Bubble formation from surface explosions in water. FGiV, no. 3, 1972, 433-439.

A mathematical model and experimental results on the motion of a liquid caused by an explosive charge blast on the free surface of a liquid are presented. The parameters describing the motion of the liquid are: E- explosion energy; ρ - liquid density; g- gravitational constant; p- atmospheric pressure; R, φ - coordinates of the liquid surface; and t- time. The mathematial model of motion of the free surface of a liquid is given in the form

$$R/R' = f\,(t/t',\ \varphi). \tag{1}$$

where R' and t' are particular functions of E, ρ, g given both for elongated and concentrated charges. The form of Eq. (1) is determined experimentally for $\varphi = 45^\circ$ and for explosions of various magnitudes, with emphasis on the elongated charges. Four characteristic film exposures of the elongated type explosions in water are presented. Test results are presented in Fig. 1.

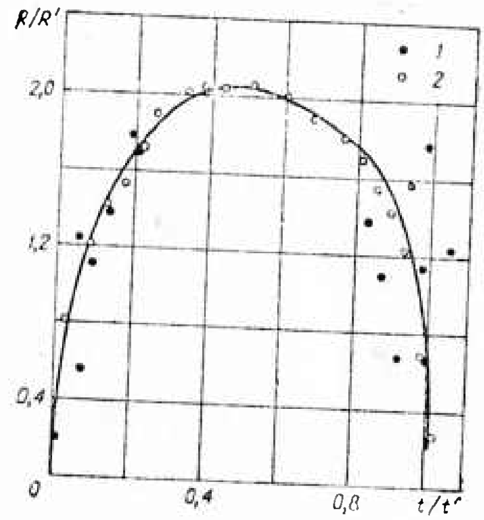

Fig. 1. Results from elongated charges.
1 - data from pick-ups; 2 - data from film exposures.

The fact that a curve can be fitted to the data points confirms the premise that the motion of a free surface liquid generated by the extended-charge explosion is adequately described by a function such as Eq. (1).

B. Recent Selections

i. Shock Wave Effects

Akhinyan, Zh. O., and A. G. Bagdoyev. Solution to the problem of shock-activated elastic body motion in a magnetic field. IAN ArmSSR, Mekhanika, no. 1, 1973, 36-50.

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3. Geosciences

A. Abstracts

Rakhimova, I. Sh. Relationship between the main crustal interfaces in the Ukraine. AN UkrRSR. Dopovidi. Seriya B. Heolohiya, heofizyka, khimiya ta biolohiya, no. 2, 1973, 157-160.

The correlation is investigated between: the depths of the Moho discontinuity (Σ) and the crystalline basement (ℓ_1); the Moho discontinuity and the Conrad discontinuity ($\ell_1 + \ell_2$ or ℓ_2); the Conrad discontinuity and the crystalline basement; and the thicknesses of the crust and basaltic layer (ℓ_3). The data analyzed were obtained from the following DSS profiles: Kiyev - Gomel (1); Shepetovka - Chernigov (2); Yagotin - Baturin (3); Piryatin - Talalayevka (4); Tsarichanka - Bogodukhov (5); Shevchenkovo - Bliznetsy (6); Nogaysk - Svatovo (7a - faults, 7b - center of the Dnepr - Donets depression); Beregovo - Vishnevets (8a - Volynya - Podol'sk plate, 8b - Cis-Carpathian foredeep, 8c - Eastern Carpathians). DSS data on the Ukrainian crystalline shield were obtained along profiles: Shepetovka - Chernigov (2'); Novoalekseyevka Shevchenkovo (6'); Dnepropetrovsk - Kirovograd (9); Novonikolayevka - Taganrog (9').

The regression equations are given in the form: $\sum = \pm a_i \pm b_i l_k$, $l_1 + l_2 = a_4 + b_4 l_1$, where $i = 1, 2, 3$, $l_k = l_1, l_1 + l_2, l_3$. Parameters calculated from the regression equation and r_i are given in Table 1.

Three groups of profiles are defined for the Ukraine (excluding the Ukrainian shield): I and II with an inverse and III with a direct relationship between Σ and ℓ_1. As the thickness of the sedimentary layer increases, the depth to the Moho discontinuity at first increases with respect to the Ukrainian shield and afterward begins decreasing. Thus, the smallest depth to the Moho discontinuity corresponds to the greatest thickness of the sedimentary layer. The three groups defined are characterized by differing ranges of ℓ_1 and Σ variation, $\ell_{1\,max}$, and Σ_{min} (see Table 2).

Table 1

Profile number	a_1, км	a_2, км	a_3, км	a_4, км	b_1	b_2	b_3	b_4	r_1	r_2	r_3	r_4
Group I												
1	39,0	46,5	25,5	14,5	−1,15	−0,64	0,53	0,48	0,86	0,58	0,90	0,40
2	39,0	50,0	25,0	14,0	−1,10	−0,87	0,53	0,56	0,86	0,77	0,95	0,46
4	47,5	—	24,0	19,5	−1,50	—	0,83	0,26	0,89	—	0,95	0,38
7^a	46,0	54,5	30,0	17,5	−1,68	−0,61	0,56	1,20	0,97	0,52	0,90	0,76
8^a	43,5	19,5	22,0	22,5	−1,42	1,00	1,00	−0,46	0,81	0,62	0,80	0,42
Group II												
3	49,5	59,0	35,0	16,5	−0,55	−0,58	0,44	0,76	0,84	0,76	0,94	0,87
5^a	43,0	51,5	35,0	18,0	−0,37	−0,45	0,33	0,85	0,85	0,89	0,87	0,99
5^b	47,5	69,5	40,0	23,0	−0,47	−0,97	0,51	0,42	0,95	0,92	0,98	0,91
6 *	42,5	47,5	33,5	15,5	−0,38	−0,37	0,32	0,63	0,88	0,71	0,87	0,77
6 **	52,5	54,0	38,0	17,5	−0,51	−0,26	0,38	0,42	0,82	0,30	0,73	0,73
Group III												
7^b	32,5	11,0	24,0	19,5	0,74	1,10	1,28	0,69	0,85	0,89	0,61	0,98
8^b	46,0	−20,5	15,0	24,5	1,50	3,00	1,36	0,49	0,90	0,90	0,98	0,97
8^c	47,0	52,0	69,5	−16,5	0,84	0,26	−0,33	3,03	0,99	0,94	0,90	0,97
Ukrainian Shield												
2′	—	4,0	14,5	—	—	1,90	1,32	—	—	0,92	0,78	—
6′ *	—	46,5	34,0	—	—	−0,37	0,31	—	—	0,73	0,87	—
6′ **	—	—	37,5	—	—	—	0,38	—	—	—	0,50	—
9	—	—	14,5	—	—	—	0,94	—	—	—	0,98	—
9′	—	−37,0	15,0	—	—	4,10	1,18	—	—	0,82	0,96	—

Note: 5^a and 5^b represent the southern and northern parts of the profile, separated by a deep-seated fault.

* Data according to Sollogub, 1967.

** Data according to Pavlenkova and Smelyanskaya, 1971

Table 2

Group	l_1, км	Σ, км	$l_{1\,max}$, км	Σ_{min}, км
I	0,5÷7,5	33,5÷47,5	4,0÷7,5	33,5÷37,0
II	0,5÷12,5	40,0÷52,5	8,5÷12,5	40,0÷45,5
III	5,0÷17,0	39,0÷67,0	15,0÷17,0	39,0÷57,0

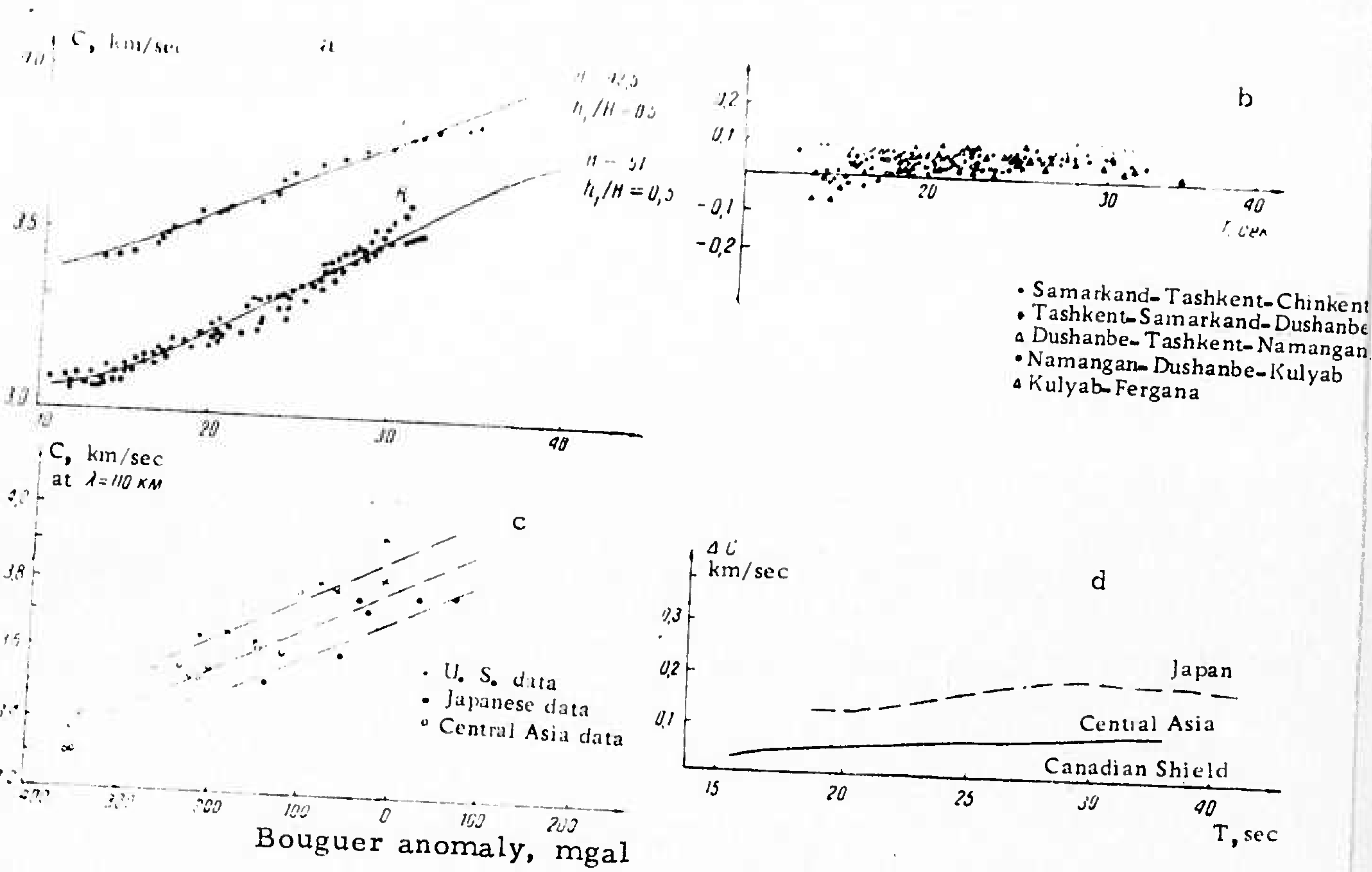
On the basis of the correlation revealed between ℓ_1 and Σ, the Moho discontinuity is hypothesized to be a boundary between rocks of different phases of metamorphism.

Peshkov, A. B., and F. Sadikov. <u>Some characteristic features on the study of the phase-dispersion velocities of surface waves in individual regions of southeastern Central Asia.</u> Uzbekskiy geologicheskiy zhurnal, no. 1, 1973, 82-86.

Love-and Rayleigh-wave dispersion data for Central Asia are interpreted in terms of shear velocity under the assumption of elastic anisotropy in the crust. Surface-wave data for Central Asia are compared with those for Japan and the Canadian shield.

Observed Love- and Rayleigh-wave dispersion curves are shown in Figure 1a. On the basis of the differences between observed Love-wave dispersion and theoretical dispersion for the crustal model derived from Rayleigh-wave data (see Fig. 1 b), it is assumed that the crust is characterized by elastic anisotropy. SH- and SV-wave velocities are found to be 3.85 and 3.32 km/sec, respectively (after corrections of 0.03 and 0.15 km/sec were introduced).

It is pointed out that differential dispersion curves for Central Asia, with intermediate tectonic activity, lies between the curves for Japan with high tectonic activity and the Canadian shield with low tectonic activity (see Fig. 1d). The same holds true for the dependence between the phase velocities of Rayleigh-waves at λ = 110 km and Bouguer anomalies (see Fig. 1c).



a- Love- and Rayleigh-wave phase-velocities observed for the Dushanbe - Tashkent - Namangan triangle; b- Differences between observed and theoretical Love-wave dispersion determined for the crustal model derived from Rayleigh-wave data; c- Relationship between Rayleigh-wave phase-velocities at λ = 100 km (sic) and Bouguer anomalies; d- Averaged differences between observed and theoretical Love-wave dispersion determined for the crustal model derived from Rayleigh-wave data for Japan, Central Asia, and the Canadian shield.

Bulashevich, Yu. P., V. N. Bashorin, V. S. Druzhinin, and V. M. Rybalka. Helium in the ground water along the Sverdlovsk deep seismic sounding profiles. IN: AN SSSR. Doklady, v. 208, no. 4, 1973, 825-828.

The results of a survey for helium conducted along the Sverdlovsk DSS profile are presented for the purpose of evaluating the possibility of detecting deep-seated faults based on the helium content in ground water. Sampling of ground water was performed at well pumping stations at depths of 60 to 120 m. The helium content was determined using PTI-6 mass spectrometers (helium leak detector).

The variation of helium content and the seismic section along the Sverdlovsk profile are shown in Figure 1. The helium content varies pronouncedly along the profile, with anomalous values reaching $30\text{-}50 \times 10^{-3}$ vol. %. All helium anomalies, except the one observed near Kamyshlov, are confined to 22 out of 26 seismically identified deep-seated faults. Large anomalies ($> 10 \times 10^{-3}$ vol. %) were observed at 17 deep faults, and smaller ones at 5 faults. A very large anomaly of 0.19 vol. % was observed at the deep-seated fault east of Shatrovo, which is accompanied by ultrabasic intrusions. It is concluded that the helium survey yielded valuable information on the identification of crustal disjunctive dislocations.

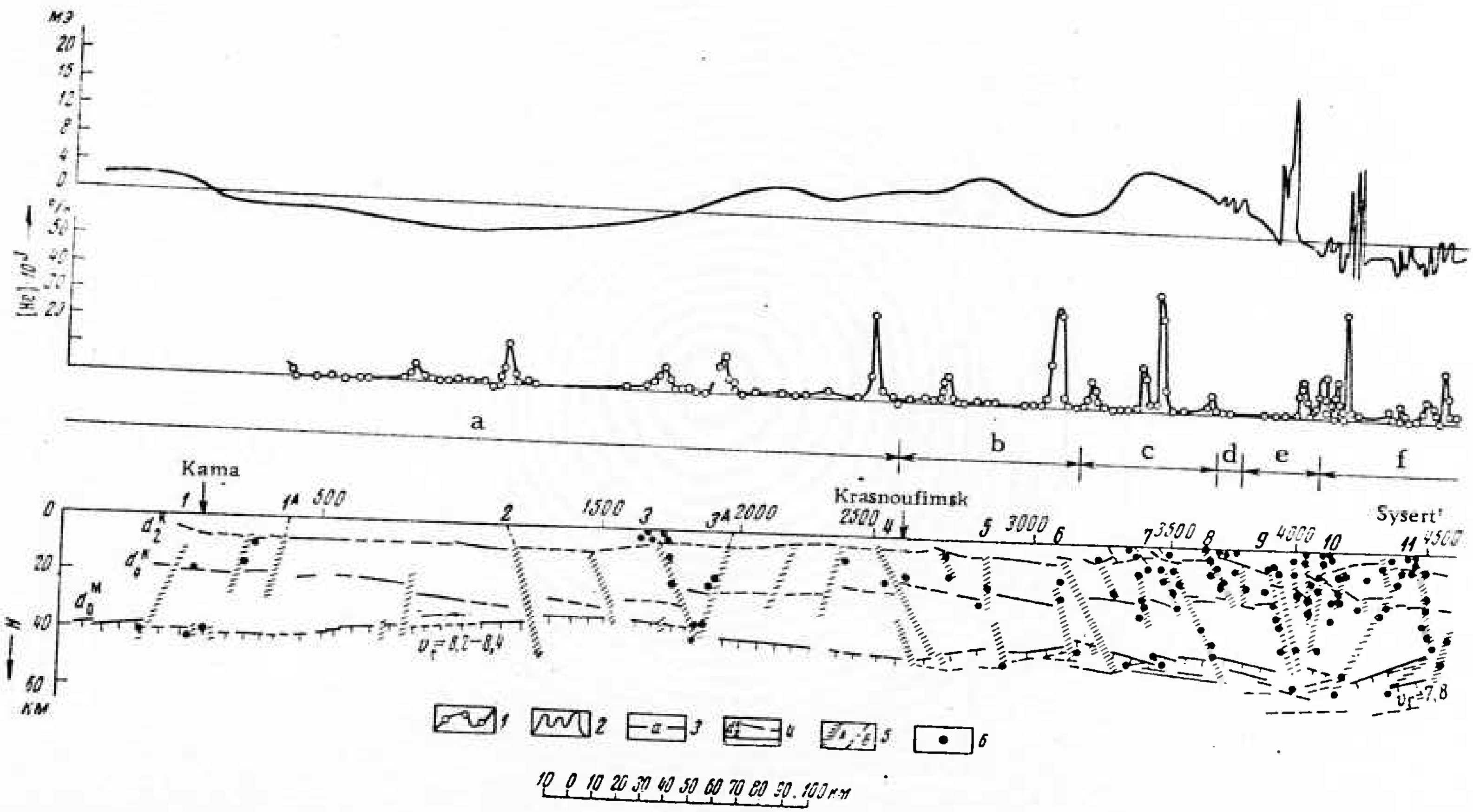


Fig. 1. Seismic Section and Variation of Helium Content and Geomagnetic Field along the Sverdlovsk DSS Profile.

1 - Helium content; 2 - vertical component of the geomagnetic field intensity; 3 - geological structures (according to Druzhinin et al., 1968): a - eastern part of the Russian platform; b - Cis-Ural foredeep; c - West Ural zone of Paleozoic folding; d - Central Ural uplift; e - Tagil-Magnitogorsk trough; f - East Ural uplift; 4 - crustal interfaces; $d_2{}^k$ - basement surface, $d_4{}^k$ - basaltic layer surface, $d_o{}^M$ - Moho discontinuity; 5 - deep-seated faults (A), surface disjunctive dislocations (B); 6 - diffraction points.

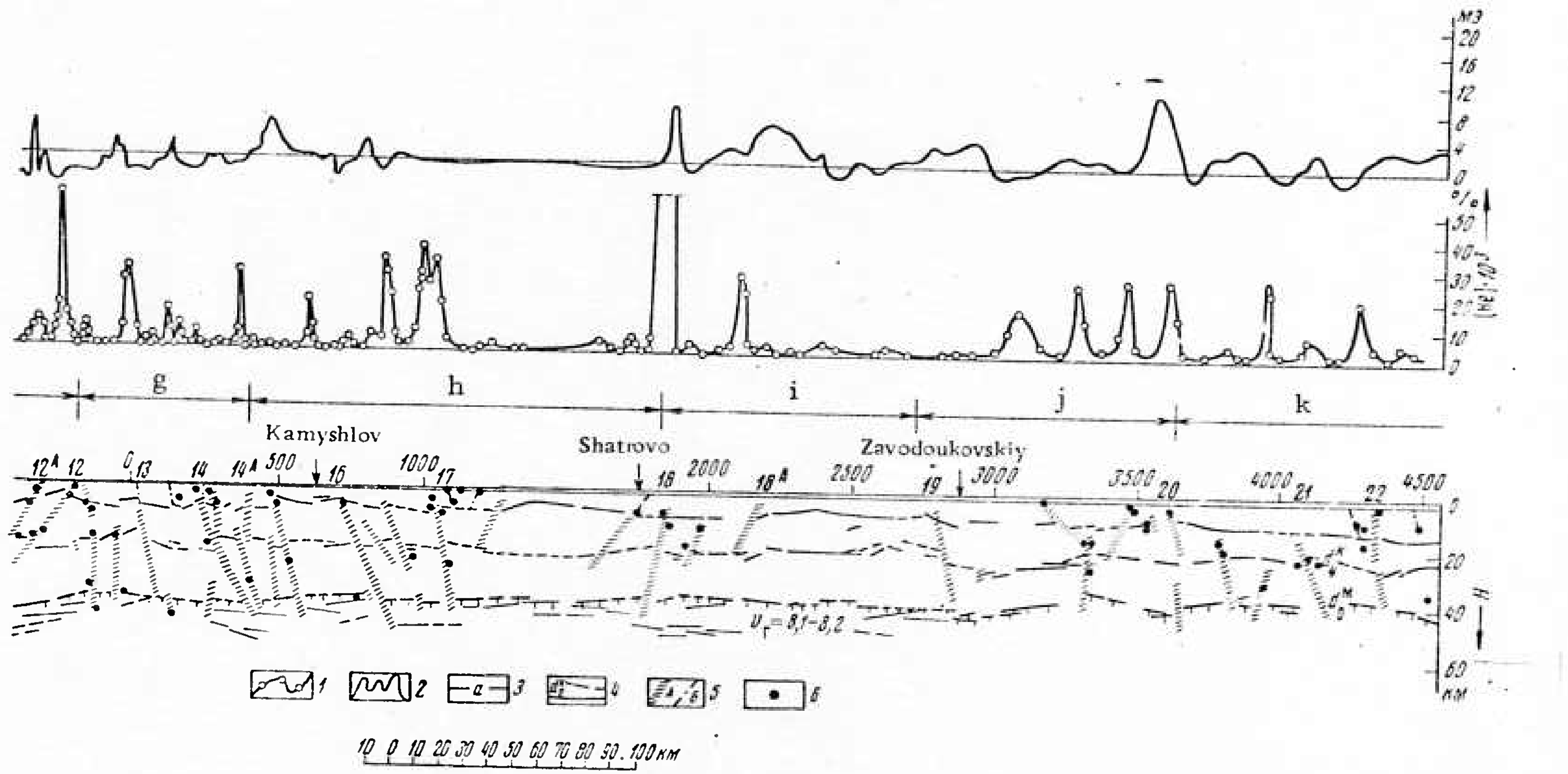


Fig. 1. Seismic Section and Variation of Helium Content and Geomagnetic Field along the Sverdlovsk DSS Profile.

1 - Helium content; 2 - vertical component of the geomagnetic field intensity; 3 - geological structures (according to Druzhinin et al., 1968); g - East Ural trough; h - Trans-Ural uplift; i - Tyumen'-Kustanay trough; j - Tobol'sk arch; k - Vagay-Ishimsk hemianticline; 4 - crustal interfaces; d_2^k - basement surface d_4^k - basaltic layer surface, d_0^M - Moho discontinuity; 5 - deep-seated faults (A), surface disjunctive dislocations (B); 6 - diffraction points.

Oblogina, T. I., V. B. Piyp, and L. A. Yudasin. Heterogeneous media with harmonic fields of the propagation velocity of seismic waves. IN: AN SSSR. Izvestiya. Fizika Zemli, no. 3, 1973, 101-108.

Conformal transformation is considered for heterogeneous media with velocity function v(x, y) for which the characteristics ln v(x, y) is a harmonic function. A method is proposed for the solution of kinematic problems based on the use of developed transformation. The problem of the recovery of the velocity function is considered. It is shown that the wave equation of the class of heterogeneous media, $\left(\frac{\partial t}{\partial x}\right)^2 + \left(\frac{\partial t}{\partial y}\right)^2 = \frac{1}{v^2(x, y)}$, can be transformed into the wave equation of homogeneous media with a velocity equal to unity of magnitude $\left(\frac{\partial t}{\partial x_1}\right)^2 + \left(\frac{\partial t}{\partial y_1}\right)^2 = 1$. Furthermore, it is shown that using this transformation, the solutions for point source problems developed for homogeneous media can be extended to the class of heterogeneous media considered. An example is given of the graphical and analytical dete-rmination of the travel times of reflected and refracted waves in a two layered medium with a horizontal interface and $v(x, y) = v_0 \, e^{\alpha x + \beta y}$.

The problem of the recovery of the velocity field for the considered class of media is set as the solution of $\frac{\partial^2 U}{\partial x^2} + \frac{\partial^2 U}{\partial y^2} = 0$, [$U = \ln v(x, y)$] in halfspace $y > 0$ for boundary condition $U(x, y)\big|_{y=0} = f(x)$, where $f(x) = \ln v(x, 0)$ is a known function, by the method of regularization. An example of the recovery of the velocity field is given for a case where $v = 1.49e^{0.17[(y+0.5)^2 - x^2)]}$. A comparison of the recovered and original velocity field showed that they agree well in the central part of the considered interval (5% error) and not so well in the boundary parts of the interval (error ~15%).

Vasil'yev, S. A. Some problems in the theory of the continuation of a wave field toward the source. IN: AN SSSR. Izvestiya. Fizika Zemli, no. 3, 1973, 35-47.

Theoretical possibilities for the sourceward continuation of pulsed and monochromatic wave fields are considered. For this purpose, the surface integral of the Kirchhoff formula was modified, and the properties of the modifications are analyzed. A criterion for the applicability of the algorithm derived to the sourceward continuation of a wave field is defined. The existence of a non-empty region where the modifications are applicable is proven. The errors in the continuation of wave field are analyzed, and the region where the algorithm is applicable to the sourceward continuation of pulsed and monochromatic fields is defined.

Gil'bershteyn, P. G., and G. V. Gubanova. Quasisliding of compressional waves in the case of a concave refracting interface. IN: AN SSSR. Izvestiya. Fizika Zemli, no. 3, 1973, 48-64.

The results of an ultrasonic model study of the effect of refracting-surface curvature on the characteristics of the compressional waves confined to it are described. The two-dimensional model used was made of duraluminum sheet (δ = 2mm), with the refracting interface consisting of plane ($R/\lambda \rightarrow \infty$) and concave ($1.8 \leq R/\lambda \leq 19.1$) sections. Both the source and receiver of ultrasonic waves were set directly on the refracting interface. A comparative analysis of the experimental amplitude graph for $P_{2\,sl}$ (sliding wave) and theoretical amplitude curve for P_{121} (head wave) demonstrated the validity of the source-receiver set up.

The principal results of the experiments are: Both on the plane section and the concave section (with $2\pi R/\lambda > 10$) of the refracting interface, sliding wave P_{2s1} (P_{12s1}) is observed; however, on the concave section, it undergoes an anomalous velocity dispersion and additional attenuation, but sustains its waveform. This wave is termed a quasisliding wave. The velocity dispersion of the quasisliding wave depends solely on the geometry of the concave interface and the velocity drop across it. For example, at $R/\lambda = 2$, its velocity decreases by 3 - 8 % ($V_{1P}/V_{2P} \approx 0.9$), 20-22% ($V_{1P}/V_{2P} \approx 0.54$) and 28% ($V_{1P}/V_{2P} \approx 0.38$). Additional attenuation of the quasisliding wave due to the curvature of the interface has significant magnitude, and at $R/\lambda < 15$ represents the major portion of the overall attenuation. It has an exponential relationship to the length of the concave section of the interface. The coefficient of additional attenuation decreases monotonically with R/λ.

The quasisliding wave generates a head wave in the overlaying medium which is also characterized by velocity dispersion and additional attenuation due to the curvature of the interface. Analysis has shown that the additional attenuation of the head wave offsets and exceeds the focusing effect, resulting in a decrease in head-wave amplitude.

Ryabinin, Yu. N. A possible mechanism for the origin of deep earthquakes. IN: AN SSSR. Doklady, v. 208, no. 4, 1973, 822-824.

A model of the focal mechanism of deep earthquakes is hypothesized, and the energy that could be released at the focus of an earthquake is estimated.

It was proposed that deep earthquakes originate as a result of rapid mechanical twinning of crystal in the substance of the earth's interior.

Model studies were carried out on cylindrical samples of tin polycrystal (h, r = 23 mm), exposed to uniaxial loads up to 2500 kg. The stress jump that occurred in the process of slow plastic deformation (see Fig. 1) was found to be caused by twinning of favorably oriented tin crystallites. The energy released at the moment of the first sudden deformation (accompanied by the main elastic shock) is estimated to be 10^6 erg/cm^3. Consequently the energy that can be released at the focus of an earthquake with a focal volume of 100 km^3 is 10^{23} ergs. Such a focus would produce a quadrantal radiation pattern.

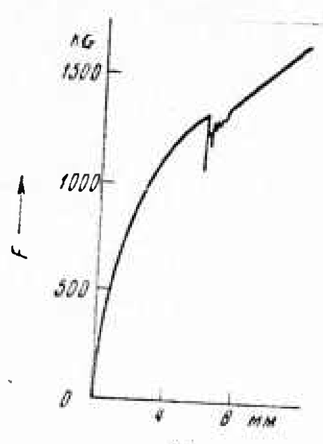


Fig. 1. Relationship of Deformation (Δh) to Axial Force (F).

Kuzin, I. P. Velocities of elastic waves in the Kamchatka focal zone. AN SSSR. Izvestiya. Fizika Zemli, no. 12, 1972, 25-29.

A method for the determination of velocity distribution within the mantle is developed using data on the anomalies (station discrepancies) of the travel times of P- and S-waves from earthquakes. Data on 128 earthquakes with $K = 9\text{-}13$, $\Delta = 50\text{-}350$ km and $h = 0\text{-}170$ km were used, as observed at the Shipunskiy seismographic station located within the Kamchatka focal zone. The Δt_p and Δt_s anomalies were determined using the Kamchatka time-tables calculated for a homogenous three-layered crust and two-layered mantle models.

The distributions of Δt_p and Δt_s over the axial plane of the focal zone are shown in Figure 1. The inferred distribution of V_p and V_s are shown in Figure 2. The inferred velocity distributions are characterized by a high-velocity zone occurring beneath Kronotskiy Bay within the 30-80 km depth range. The maximum values observed in this zone are $V_p = 8.6$ km/sec and $V_s = 4.5$ km/sec.

The velocities observed within the 30-80 km depth range beneath Kronotskiy Peninsula and the southern part of Kamchatka Bay are very close to the velocities of the accepted mantle model ($V_p = 7.8$ km/sec, $V_s = 4.5$ km/sec). The minimum velocity values of $V_p = 7.4$ km/sec and $V_s = 4.4$ km/sec are observed at a depth of 30 km.

The inferred velocity models were checked by comparing the travel times of P- and S-waves observed at the Shipunskiy station with those calculated for the inferred velocity models. It was found that the differences do not exceed ± 0.2-0.3 sec.

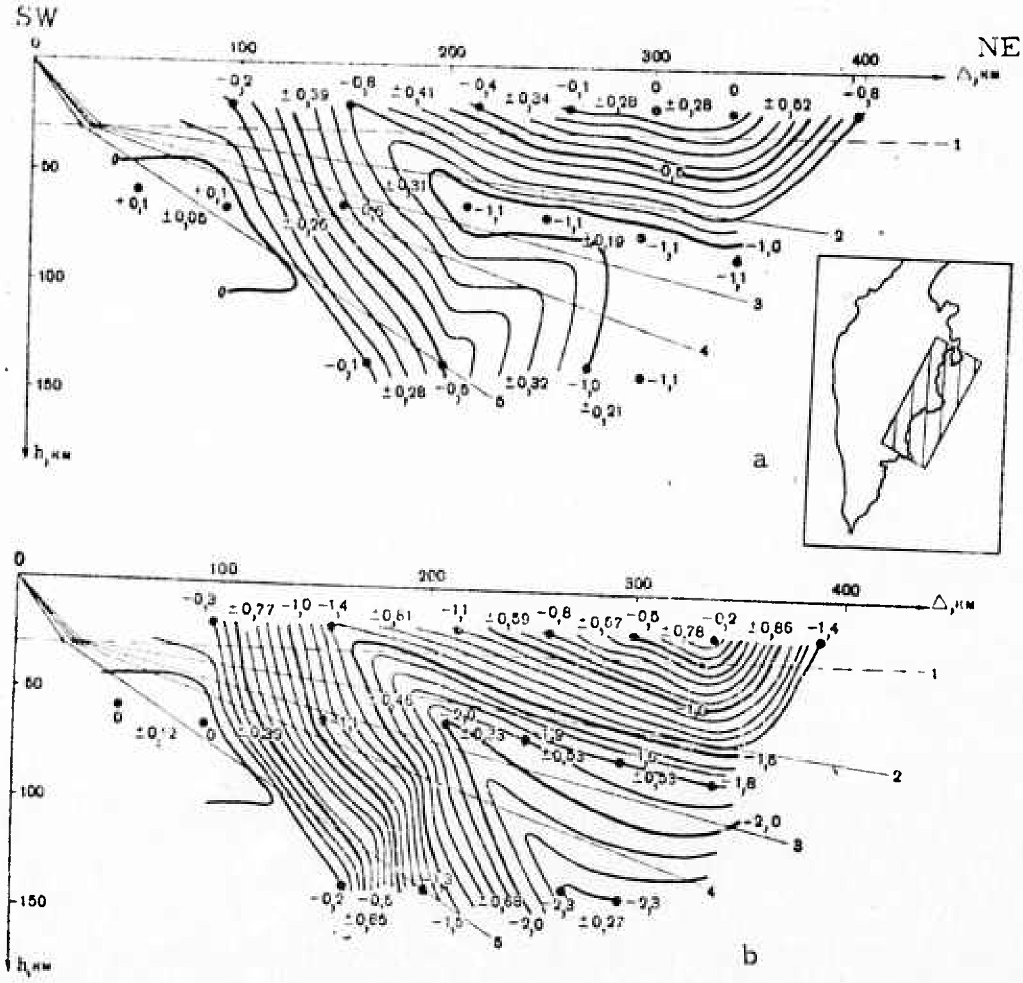


Fig. 1. Distribution of Δt_p (a) and Δt_s (b) over the Axial Plane of the Focal Zone.

Dots represent gravity centers for earthquake groups, Lines 1 thru 5 - seismic rays; Location of the axial plane is shown in the inset map.

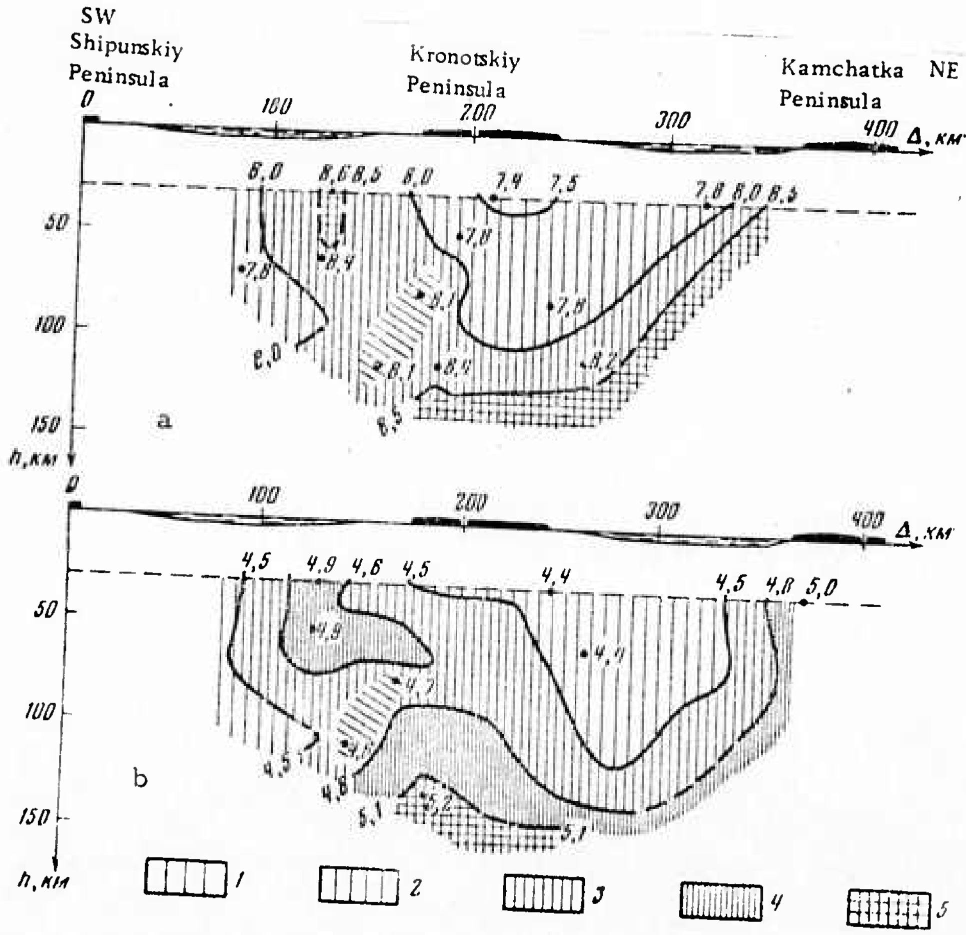


Fig. 2. Distribution of V_P (a) and V_S (b) over the Focal Zone.

1 - V_P < 7.5 km/sec; 2 - V_P = 7.5-8.0 km/sec, V_S < 4.5 km/sec, 3 - V_P = 8.0-8.5 km/sec, V_S = 4.5-4.8 km/sec; 4 - V_S = 4.8-5.1 km/sec; 5 - V_P > 8.5 km/sec, V_S > 5.1 km/sec.

The effect of the homogeneous layered mantle on the results was evaluated. It was found that the seismic rays plotted for a gradient mantle are very close to those for a homogeneous layered mantle.

The effect of possible error in the determination of the focal coordinates of earthquakes is evaluated. The inferred velocity models are found to be reasonably stable with respect to these errors.

Fomenko, K. Ye. Deep structure of the peri-Caspian depression, based on geological and geophysical data. IN: Moskovskoye obshchestve ispytateley prirody. Byulleten'. Otdel geologii, v. 47, no. 5, 1972, 103-111.

The results of deep crustal studies in the peri-Caspian depression are summarized. Maps of the basement surface and the Moho discontinuity relief have been compiled using seismic (CMRW and DSS method), gravity, and magnetic data.

The basement of the peri-Caspian depression does not have the same characteristics over the entire depression. In the marginal areas of the depression, it is characterized by seismic waves with V_r = 6.5 km/sec. The refractor velocity of waves from the basement surface gradually increases toward the central part of the depression, reaching 7.2 km/sec. It appears that the "granitic" layer gradually thins out, and in the central part of the depression, the sedimentary layer is underlain directly by the "basaltic" layer. In the marginal parts of the depression, the basement surface (V_r = 6.5 km/sec), intersected by peripheral faults, descends step-wise towards the central part of the depression, whereas the "basaltic" layer surface rises (see Figs. 1 and 2).

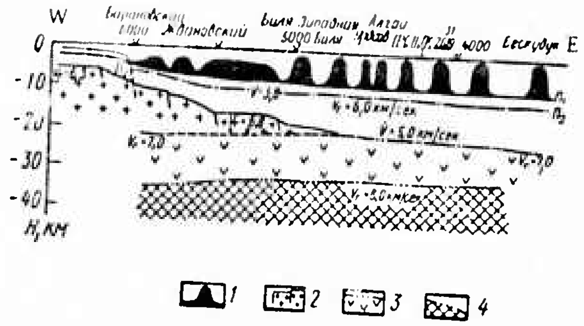


Fig. 1. Seismic Section along CMRW-DSS Profile CX (see Fig. 3below).

1 - Salt domes; 2- Precambrian crystalline basement surface; 3 - "basaltic" layer surface; 4- Moho discontinuity.

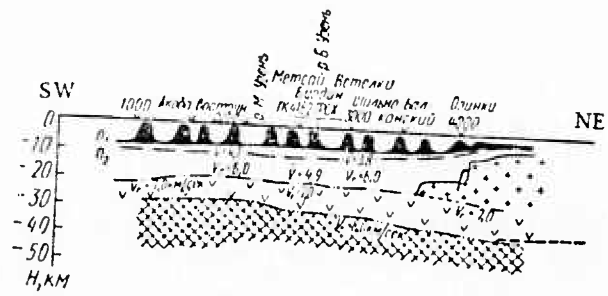


Fig. 2. Seismic Section along CMRW-DSS Profile CII (see Fig. 3 below).

(Note: Designations the same as in Fig. 1).

The Moho discontinuity (studied along the DSS profiles shown in Figure 3) rises from the marginal parts towards the central part of the depression, i.e., from 36 to 27 km (profile CII, Fig. 1) and from 40 to 22 km (profile CXI Fig. 3).

In the marginal parts of the depression, the Moho discontinuity occurs at depths of 36-38 km (Fig. 3). Two local uplifts of the Moho discontinuity, with minimum depths of 22 and 29 km, are evident in the eastern and western part of the depression, respectively. They are separated by a relative downwarp, coinciding approximately with the Ural river. The uplifts coincide with gravity maxima.

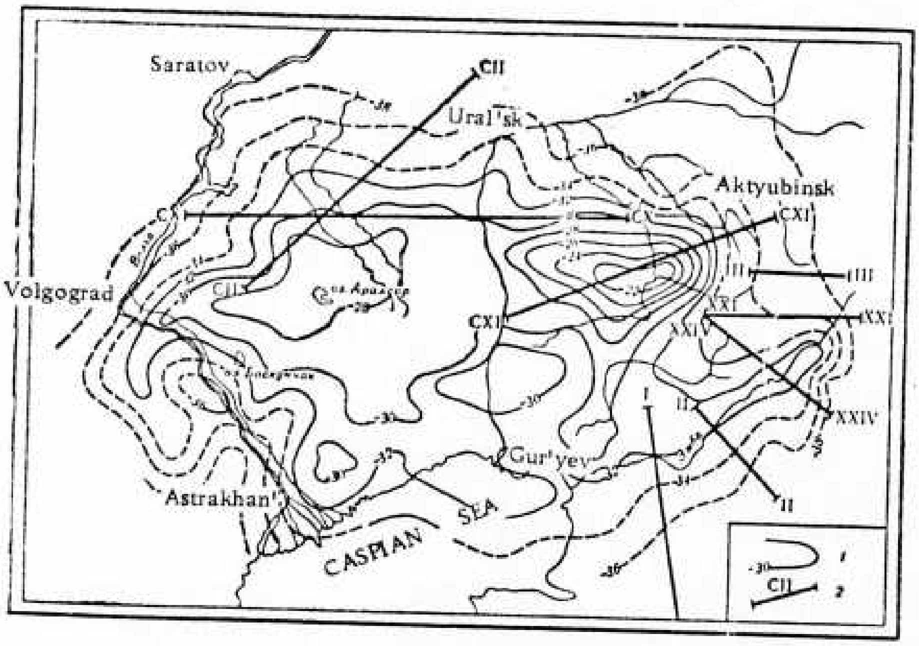


Fig. 3. Map of the Moho Discontinuity in the Peri-Caspian Depression.

1 - Contour lines of the Moho discontinuity;
2 - regional CMRW-DSS profiles.

Thus, the crust in the peri-Caspian depression differs sharply from the crust in the adjacent regions. It is characterized by a "granitic" layer which thins out in the central part of the depression and a "basaltic" layer whose thickness varies from 20 km, in the marginal parts, to 5-7 km in the central part of the depression. Minimum thickness of the "basaltic" layer coincides with the minimum crustal thickness.

B. Recent Selections

Abdulin, A. A., et al. Deep crustal structure of Mugodzhary, based on seismic data. IN: AN SSSR, et al. Glubinnoye seysmicheskoye zondirovaniye (Deep seismic sounding*). Alma-Ata, Izd-vo Nauka, 1973, 170-186.

Al'ter, S. M., et al. Seismic studies of the crustal structure of the northwestern part of the Caspian depression. IN: AN SSSR, et al. Glubinnoye seysmicheskoye zonderovaniye (Deep seismic sounding). Alma-Ata, Izd-vo Nauka, 1973, 194-203.

Antonenko, A. N., et al. Status and development prospects of the method of earthquake converted waves. IN: AN SSSR, et al. Glubinnoye seysmicheskoye zondirovaniye (Deep seismic sounding). Alma-Ata, Izd-vo Nauka, 1973, 52-65.

Belousov, V. V. Certain questions in the structure and development of the tectonosphere and problems in its study. IN: AN SSSR, et al. Glubinnoye seysmicheskoye zondirovaniye (Deep seismic sounding). Alma-Ata, Izd-vo Nauka, 1973, 9-15.

Belyayevskiy, N. A. Geological results of deep seismic sounding of the crust. IN: AN SSSR, et al. Glubinnoye seysmicheskoye zondirovaniye (Deep seismic sounding). Alma-Ata, Izd-vo Nauka, 1973, 15-27.

Berzon, I. S. Seismic models of real media. IN: AN SSSR, et al. Glubinnoye seysmicheskoye zondirovaniye (Deep seismic sounding). Alma-Ata, Izd-vo Nauka, 1973, 72-83.

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* This collection of articles consists of papers presented at the Second All-Union Conference on the Study of the Earth's Crust and Upper Mantle by Explosion Seismology Methods, held in Alma-Ata, USSR in November 1969.

Danchiv, A., and R. Comsa. Modeling of seismic phenomena using the finite element method. Revue Roumaine de geologie, geophysique et geografie. Serie de geophysique, v. 17, no. 1, 1973, 63-75.

Davydova, N. I., and G. G. Mikhota. The study of the thin structure of the Mohorovicic discontinuity on the continent. IN: AN SSSR, et al. Glubinnoye seysmicheskoye zondirovaniye (Deep seismic sounding). Alma-Ata, Izd-vo Nauka, 1973, 93-100.

Gliko, A. O. Seismic wave attenuation due to thermal relaxation. IN: AN SSSR. Izvestiya. Fizika Zemli, no. 4, 1973, 79-83.

Iliyeva, M. A. Some results from the determination of seismic-wave attenuation coefficients, based on the amplitude curves of head (refracted) waves. IN: Bolgarskaya akademiya nauk. Doklady, v. 26, no. 1, 1973, 55-58.

Kagan, Ya. Ya. A probability description of seismicity. IN: AN SSSR. Izvestiya. Fizika Zemli, no. 4, 1973, 10-23.

Khalevin, N. I., et al. Study of the upper crust of the Urals by extensive seismic sounding using industrial explosions. IN: AN SSSR, et al. Glubinnoye seysmicheskoye zonderovaniye (Deep seismic sounding). Alma-Ata, Izd-vo Nauka, 1973, 130-137.

Khrychev, B. A., et al. Block structure of the crust along the Temirtau-Kuybyshev profile. IN: AN SSSR, et al. Glubinnoye seysmicheskoye zondirovaniye (Deep seismic sounding). Alma-Ata, Izd-vo Nauka, 1973, 160-170.

Kosminskaya, I. P., and N. I. Pavlenkova. Wave fields and crustal models. IN: AN SSSR, et al. Glubinnoye seysmicheskoye zondirovaniye (Deep seismic sounding). Alma-Ata, Izd-vo Nauka, 1973, 83-92.

Kosminskaya, I. P., and N. N. Puzyrev. Methodological problems in deep seismic sounding. IN: AN SSSR, et al. Glubinnoye seysmicheskoye zonderovaniye (Deep seismic sounding). Alma-Ata, Izd-vo Nauka, 1973, 42-52.

Lysyakov, L. M., et al. Extensive studies of the crust of Kazakhstan by deep seismic sounding and seismological methods. IN: AN SSSR, et al. Glubinnoye seysmicheskoye zondirovaniye (Deep seismic sounding). Alma-Ata, 1973, 186-193.

Molodenskiy, M. S., and M. V. Kramer. The Earth's structure based on the frequencies of its natural oscillations. IN: AN SSSR. Izvestiya. Fizika Zemli, no. 4, 1973, 3-9.

Nikitin, A. A., and A. K. Yanovskiy. Recursion filtering algorithms for the digital processing of seismic records. IN: AN SSSR. Izvestiya. Fizika Zemli, no. 4, 1973, 37-48.

Obolentseva, I. R., and L. G. Dantsig. Characteristics of the spatial polarization of passing compressional and converted waves in the case of an inclined boundary. Geologiya i geofizika, no. 4, 1973, 93-102.

Pavlenkova, N. I., et al. Velocity sections of the basic geostructures of the Ukraine. IN: AN SSSR, et al. Glubinnoye seysmicheskoye zondirovaniye (Deep seismic sounding). Alma-Ata, Izd-vo Nauka, 1973, 225-236.

Pushkarev, I. K., et al. Certain problems in deep seismic sounding methods for studying the complex structure of the crust. IN: AN SSSR, et al. Glubinnoye seysmicheskoye zondirovaniye (Deep seismic sounding). Alma-Ata, Izd-vo Nauka, 1973, 114-120.

Puzyrev, N. N. Low-detail research by the deep seismic sounding method. IN: AN SSSR, et al. Glubinnoye seysmicheskoye zondirovaniye (Deep seismic sounding). Alma-Ata, Izd-vo Nauka, 1973, 120-129.

Radzhabov, M. M. Seismic studies of the crust in the southeastern downwarp of the Greater Caucasus and adjacent depressions. IN: AN SSSR, et al. Glubinnoye seysmicheskoye zondirovaniye (Deep seismic sounding). Alma-Ata, Izd-vo Nauka, 1973, 203-211.

Roman, C. Travel-time residuals in the Carpathians and plate tectonics (in English). Revue Roumaine de geologie, geophysique et geografie. Serie de geophysique, v. 17, no. 1, 1973, 77-83.

Sollogub, V. B., et al. Deep structure of the Ukrainian shield, based on deep-seismic sounding data. IN: AN SSSR, et al. Glubinnoye seysmicheskoye zonderovaniye (Deep seismic sounding). Alma-Ata, Izd-vo Nauka, 1973, 211-224.

Traian, I., and I. Sieglinde. Energy study of the earthquakes from the Vrancea region; Data about upper mantle (in English). Revue Roumaine de geologie, geophysique et geografie. Serie de geophysique, v. 17, no. 1, 1973, 85-91.

Vol'vovskiy, I. S. Seismic wave velocities in the crust and upper mantle of the USSR. IN: AN SSSR, et al. Glubinnoye seysmicheskoye zondirovaniye (Deep seismic sounding). Alma-Ata, Izd-vo Nauka, 1973, 28-42.

Yesenov, Sh. Ye., et al. Seismic studies of the crust in Kazakhstan and their basic results. IN: AN SSSR, et al. Glubinnoye seysmicheskoye zondirovaniye (Deep seismic sounding). Alma-Ata, Izd-vo Nauka, 1973, 151-159.

MONOGRAPHS

AN SSSR. Institut fiziki Zemli. Zemletryaseniya v SSSR v 1968 godu (Earthquakes in the USSR in 1968). Moskva, Izd-vo Nauka, 1972, 220 p.

Akademiya nauk UzbSSR. Institut seysmologii. Seysmichnost' zapadnogo Uzbekistana (Seismicity of western Uzbekistan). Tashkent, Izd-vo Fan, 1972, 151 p.

4. Particle Beams

A. Abstracts

Grishayev, I. A., and A. M. Shenderovich. Acceleration by chopping of an intensive electron beam. ZhTF, no. 11, 1972, 2409-2412.

A theoretical and experimental study is presented of the accelerating electric field generated by chopping of an intensive electron beam transiting through various resonance systems. Shock excitation is analyzed of systems consisting of a cylindrical resonator, a parallel oscillatory circuit, and a long linear pulse shaper. It is shown that in all three systems analyzed a high potential vorticity field is generated which during the first half period of oscillation, can be used to accelerate charged particles. Advantages of each system are cited. Braking fields generated by turning on the electron beam are shown to be smaller than the accelerating field.

Theoretical conclusions were verified experimentally. The excitation circuit consisted of a 17 kv linear pulse shaper, an electron gun, a capacitor with choke coils and a shorting discharger. The oscillatory circuit was a capacitive impedance coupling. The electron beam intensity peaked in 3μsec and decayed in 0.1 μsec. Oscilloscope traces of the oscillatory circuit voltage show a sharp peak at the end of the first half-period. The amplitude of the second accelerating period was ~20 kv, or three times higher than the decelerating voltage during the first half-period. Waveforms of the pulsed current and oscillatory voltage are included.

A related patent disclosure by Grishayev et al was covered in an earlier report (March 1973, p. 131).

Zaydin, D. G., and V. K. Karpasyuk. Combining radial and phase stability in an Alvarez linear accelerator. ZhTF, no. 11, 1972, 2427-2429.

It was previously established by Vlasov (Teoriya lineynykh uskoriteley Atomizdat, Moskva, 1965) that separate radial and phase stabilities of particle motion in linear accelerators without any special focusing device are possible, at a constant synchronous phase in the acceleration process, and that a sufficiently rapid growth of accelerating wave amplitude can be achieved along the accelerator. The present work concerns the theoretical analysis and modelling of combined particle motion processes in a low energy Alvarez linear accelerator, without any additional focusing device. A system of linear equations is developed for phase and radial motion in an axisymmetrical wave using Newton's equation plus a number of nonstandard assumptions; modelling was done by computer. It is shown that in a comparatively low energy range, there exists a region, sufficiently wide for practical purposes, of combined radial and phase stability. This assumes the usual axisymenetrical structure with drift tubes at constant synchronous phase along the accelerator, and that the amplitude of the accelerating wave increases along the accelerator. Combined radial and phase stability does not occur unless these conditions are met, e.g., in the case of constant accelerating wave amplitude, either the radial or the phase motion becomes instable.

Rudakov, L. I. Electron beam drag in a plasma with a high level of Langmuir turbulence. DAN SSSR, v. 207, no. 4, 1972, 821-823.

The author discusses the possible existence of a new turbulent state, which can arise and be sustained owing to beam instability under the condition of beam excited oscillations for which

$$w / (nT) > \overline{\Delta k^2} r_D^2, \tag{1}$$

where Δk = spectrum width, $r_D = V_{T_e} / P$, $V_{T_e} = (2T_e/m)^{\frac{1}{2}}$, and w - turbulent energy density in the plasma. At the above condition, energy bunching of Langmuir oscillations occurs, as a result of which coupled stages, qualitatively different from traveling waves, are formed in the plasma. Equations are obtained for Langmuir oscillations (solitons) localized in space, and an expression is derived for soliton energy. An analysis is given of the interaction between solitons and charged particles, in which the energy yielded by the beam is transferred to solitons and thermal energy of plasma electrons. Part of the beam energy is also transferred to ions because of their resonance interaction with the electric potential of the solitons; as a result, the solitons attenuate. It is shown that an electron beam can excite and maintain strong Langmuir turbulence with a medium energy density $(V_{T_e}/u)^2 < \omega/(nT) < 1$, representing a set of solitons. The author emphasizes that it is necessary to take into account this effect of interaction between solitons and charged particles when investigating an initial arbitrary excitation in plasma.

Koba, V. V., and I. A. Sakharova. Method of measuring tungsten electrode working edge temperatures in a high current discharge. IN: Sbornik. Tezisy dokladov V Vsesoyuznoy konferentsii po generatoram nizkotemperaturnoy plazmy, Novosibirsk, v. 2, 1972, 36-39. (RZhMekh, 12/72, no. 12B101) (Translation)

Cathode temperatures of type DKsR5000 and DKsR10000 spherical xenon tubes were measured as functions of discharge current. Cathode surface temperature was determined from photodiode sensing of the heated cathode, following preliminary calibration against tungsten emission. Measurement error in the 2000°-3000° K range was 7--10%. In addition to temperature and discharge current, the electrode voltage was recorded, together with internal pressure and thermal flux in the anode and cathode.

Akhiyezer, I. A., and V. T. Lazurik-El'tsufin. Dynamic effect from passage of charged particles beams in solids. ZhETF, v. 62, no. 5, 1972, 1776-1779.

Dynamic loads are generated from the passage of a high-velocity charged particles beam through matter, which excite elastic vibrations in the body. The character of these loads and their dependence on beam and target parameters are investigated in the article. Under the assumption that the beam energy is not too high, the longitudinal load (with respect to the incident beam) is determined in cases pertaining to electron (positron) and proton cylindrical beams. Rigorous formulas for two limiting cases are

derived: for a thin plate ($h = d/\theta$) in which the beam passing through is affected very little ($\theta << 1$, $\Delta E_t << E_o$) and a thick plate ($h >> l$), in which the beam is completely absorbed. In these expressions d = beam diameter, θ = mean-square of the scattering angle, ΔE_t = total energy loses of beam particles in the plate, E_o is initial energy, ℓ = length of free path of particles, and h = plate thickness. It is shown that in the range of moderate energies, loads increase linearly with the growth of energy. At large energies, the loads in the case of electron (positron) beams do not depend on energy and in the case of a proton beam the loads decrease with the increase of energy. Numerical calculations were carried out for aluminum, copper and lead plates with h = 0.01 cm. The dependence of dynamic loads on beam energy for these plates is presented graphically. An experimental verification of the theory is proposed, by measuring the amplitude of sound waves excited by a particle beam.

Kozlov, N. P., A. A. Lyapin, and V. I. Khvesyuk. Method of calculating the cathode region (field emission regime). IN: Sbornik. Tezisy dokladov V Vsesoyuznoy konferentsii po generatoram nizkotemperaturnoy plazmy, Novosibirsk, v. 3, 1972, 12-14. (RZhMekh, 12/72, no. 12B99).

An approximate method is suggested for calculating cathode region parameters (cathode drop, electron current fraction, neutral concentrations, etc) as functions of thermophysical characteristics of the cathode material and the excitation cross-section values of cathode atoms at a metastable level. The authors use a previously obtained solution to a system of cathode equations supplemented with a thermal conductivity

equation and a relationship correlating the ion current density with the neutral concentrations and the cathode gas ionization level. The cathode material vaporization process is allowed for, based on the Langmuir law. Calculations were made of mercury cathode current at a single cathode spot with a lifetime of 10^{-7} sec. The results are in good agreement with experimental data.

Grishayev, I. A., G. D. Kramskoy, A. I. Zukov, and G. L. Fursov. Interaction of a beam with lateral waves in periodic structures of heavy-current linear electron accelerators. IN: Tr. 2-go vses soveshch po uskoritelyam zaryazhen. chastits, 1970, v. 2, Moskva, nauka, 1972, 72-78. (RZh Elektr, 1/73, no. 1A278)(Translation)

Attempts were made to measure instability parameters at different conditions of transition and interaction of a beam with periodic structures of a linear accelerator. Relationships were investigated of critical current, amplitude and frequency of beam-guided signals in EH_{11} and ET_{21} modes, and also the beam acceleration coefficient, as functions of: the initial lateral beam dispacement as an integral relative to iris waveguide axis, the waveguide Q in the EH_{11} mode, the linear focussing magnetic field of the solenoid, the diameter of the beam injected in accelerator and the waveguide terminal matching equipment. It was found that values of initial displacement (constant in time) and angle of incidence of the beam relative to the periodic structure axis do not affect instability parameters. The critical current in a first approximation is inversely proportional to Q of the structure, and rises linearly with increase of focusing magnetic field.

Golovin, V. N., V. N. Podshivalov, N. P. Sobenin, and E. Ya. Shkol'nikov. Calculating waveguide clusters with extreme requirements for beam characteristics of heavy-current linear electron accelerators. IN: Tr. 2-go vses soveshch. po uskoritelyam zaryazhn. chastits, 1970. v. 2. Moskva, nauka, 1972, 68-70. (RZhElektr, 1/73, no. 1A276). (Translation)

Waveguide clusters without additional equipment for initial bunch formation are simple in assembly and adjustment. Calculation of such clusters with a high capture coefficient and phase-energetic distribution presents a considerable difficulty. The problem is still more complicated, if the cluster is intended for heavy-current beam formation, because problems of load current and space charge is intensive phase motion have not been adequately treated. A method is discussed of calculating the cited problem in connection with the designing of waveguide clusters for heavy-current accelerators. An extremal calculating method of linear dynamics is analysed taking into account load current and space charge.

Pasynok, A. I., N. S. Repalov and N. A. Khizhnyak. On the parametric instability theory of a confined electron beam. ZhTF, no. 12, 1972, 2452-2457.

The work considers electromagnetic waves in a modulated electron beam, confined in a metallic waveguide. It is shown that such a scheme is unstable in relation to extended axial modes. Dispersion equations were obtained and analysed for various limiting conditions. It was found that in a beam of limited radius the resonance condition is a function of signal

frequency, which results in a limitation in the amplified frequency band at fixed beam parameters and modulating fields. The instability increment depends on frequency in the region $\omega < \omega_o$, and tends to zero as $\omega \rightarrow 0$.

Tkach, Yu. V., Ya. B. Faynberg, I. I. Magda, Ye. A. Lemberg, and N. P. Gadetskiy. <u>Stimulated emission from the interaction of heavy-current relativistic beam with plasma.</u> UFZh, no. 1, 1973, 44-46.

Tkach et al. have published several papers on emission generated by heavy current interaction with plasma (cf. Jan. 1973 Report, p. 79). In the present article, results are described on lasing from a plasma-beam discharge using a heavy-current relativistic beam. The experimental sketch is given in Fig. 1. An electron beam at 30 ka and energy of 0.7 Mev

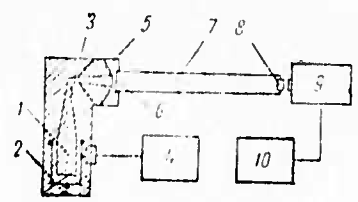

Fig. 1. Beam-plasma experiment

1- Coaxial double pulse shaping line, water dielectric; 2- water discharger; 3- coaxial transformer; 4- pulse generator (500 kv); 5- vacuum diode chamber; 6- aluminum foil anode, 20-50 μ; 7- interaction chamber (length = 270 cm, diameter = 14 cm); 8- quartz window; 9- monochromator and photomultiplier; 10- oscillograph.

at 30 nsec was formed by a cylindrical double line, which was charged from a Marx bank and designed for an output voltage of 5×10^5 v. A needle-form or encrusted cathode was used as an electron source, connected to the pulse shaping line through a coaxial transformer. Beam current density reached 6 ka/cm^2. Waveforms of beam current and vacuum diode cathode voltage are shown in Fig. 2. The working gas used was molecular nitrogen,

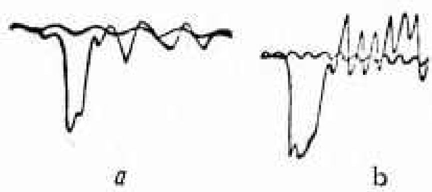

Fig. 2. a) oscillogram of cathode voltage (calibration signal 10 MHz) b) oscillogram of beam current (calibration signal 100 MHz).

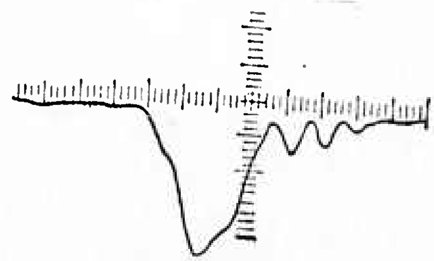

Fig. 3. emission waveform at λ = 3371 Å (one division = 10 nsec).

because of its comparatively high upper level lifetime (40 nsec) and high gain in $C^3\pi_i$ - $B^3\pi_g$ conversion inherent in the second positive N_2 system.

Superradiance was obtained at wavelengths of 3195 Å, band 1→0; 3371 Å, band 0→0 (Fig. 3); and 3577 Å, band 0→1. The pressure range in which the emission was recorded was within 10^{-1}-3 torr limits; maximum radiation corresponded to 1.0 torr, and gradually decreased with change of pressure from this level. Radiation dispersion did not exceed 2°. Measurements also showed that the relationships of x-ray and r-f emission intensities as functions of pressure were analogous to that of stimulated emission. Power levels for all three types was found to reach 10^5 w in 1.5×10^{-8} sec. An estimation is made of high-frequency oscillation increment time and is compared with pumped level lifetime. The instability increment δ was determined to be 10^{10}/sec for beam density = 10^{10} cm^{-3}. The characteristic heating time of the plasma electron component was 10^{-8}-10^{-9} sec, which makes generation in self-restricted transitions fully possible.

Mufel', V. B., and V. A. Skubko. Methods of phasing accelerating sections in a linear electron accelerator. Author's certificate, USSR, no. 352611, published June 17, 1970. (Otkr izbr, 4/73, p. 164).

A method is suggested for phasing accelerating sections by means of a phase inverter in a linear electron accelerator. For improved precision, a part of the pulsed current is periodically admitted into the phasing section. The accelerating voltage is detected at the output, and pulse differential amplitude is used to regulate the phase of the section.

Fakhrutdinov, E. N. Pulse gas-discharge gun with a high specific electron beam power. IN: Trudy Tomsk. in-ta. radioelektron. i elektron. tekhn, no. 7, 1972, 30-33. (RZhElektr, 1/73, no. 1A297) (Translation)

A description is given of a pulsed gas-discharge electron gun, the operation of which is based on electron extraction through the hole in modified Penning tube anode. High pressure electrons, extracted from the pulsed gas discharge, initiate a supplementary discharge, which significantly increases the output current. Use of a probe system in electron extraction and electrostatic focusing in the accelerating gap yields beams with a high power concentration. The specific beam power achieved is sufficient for dimensional processing of solids and refractory materials.

Pedenko, N. S., Ye. I. Lutsenko, and Ya. B. Faynberg. Heavy-current accelerator with a plasma cathode. IN: Fiz. plazmy i probl. upravl. termoyader. sinteza. Resp. mezhved. sb., no. 3, 1972, 30-33. (RZhF, 12/72, no. 12A418)

A variant of a linear plasma betatron is described designed for high voltage operation. Intense electron beams are obtained with currents≈5 ka at 100 kv or 2 ka at 200 kv. Beam electrons are drawn from an increased plasma concentration region in the plasma cathode.

Zhukov, M. F., A. S. An'shakov, G. H. B. Dandaron, and M. I. Sazonov. Investigating tungsten cathode erosion in nitrogen. IN: Fiz. dugovogo razryada. Novosibirsk, 1972, 142-151. (RZhF, 12/72, no. 12G167).

Characteristics of tungsten cathode erosion in nitrogen were investigated, using a high-power plasmatron with an arc current in the 100-1000 a range. Relationships were determined for thermal flux and current density in cathode, and specific cathode erosion, as functions of arc current. It was found that current density was practically independent of arc current, attaining 1.5×10^4 a/cm^2 in argon. It is noted that in nitrogen, cathode melting cannot be prevented, while in an argon discharge a melt-free mode is possible by using a thoriated tungsten cathode. Stable nonmelting operating conditions of the cathode in nitrogen or other media is possible only by using activated W with a work function < 2.5 ev. Specific erosion for a thoriated tungsten cathode in a wide range of arc currents in Ar, N_2 and H_2 lies within limits of $(1\text{-}10) \times 10^{-9}$ g/a/sec.

Kozlov, N. P., and Yu. S. Protasov.
Radiation properties of a dense plasma focus. TVT, no. 6, 1972, 1319-1320.

Radiation properties of a dense plasma focus were investigated in accelerators with coaxial and end-type accelerating electrodes. Discharge was generated by a 600 μf condenser bank, which supplied 340 ka at an initial voltage U_o = 5 kv. Teflon plus the erosion products of the Cu electrode were used as the working medium. The plasma focus was formed at $U_o \geq$ 2 kv, at the moment of maximum discharge current, and lasted for 12 μsec of the first half-cycle (~23 μsec). Plasma spectra were measured by a quartz spectrograph in the 2000-6000 Å range. The electron temperature as a function of FII line intensities was ~ 3.5 ev. The temperature time dependence based on line spectra self-reversal was investigated using a standard source. Results show that the temperature at the moment of maximum compression in the focus zone was ~5 ev. A bismuth bolometer was used to register radiant energy. The relation of luminescent energy to that stored in the condenser battery decreased with a rise of U_o, probably owing to a sharp increase of reabsorption in the focus zone. Results of the radiation measurements are given in Table 1; the relative measurement error was 5-7%.

TABLE 1

Condenser energy, joules	Radiation energy, joules		
	Accelerators		
	Coaxial	Coaxial, bolometer inside the electrode	End-type
300	24	21	32
1200	51	62	70
2200	73	85	190

In regions above 2000 Å, the measured radiation energy increased by 10-15%. When a fluorite filter, transparent to wavelengths below 1180 Å, was placed in front of the bolometer, the radiation energy was ~45% of the total. The metallic plasma radiation energy increased by 40-50 % compared to fluorocarbon plasma. Fig. 1 plots the radiation power at different U_o as a function of time, and Fig. 2 shows the test arrangement of the bolometer. The authors conclude that the self-focusing of the plasma

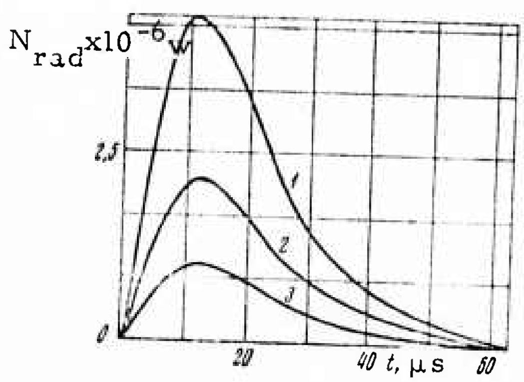

Fig. 1. Radiation power.

1 - U_o = 3 kv; 2 - 2 kv; 3 - 1 kv.

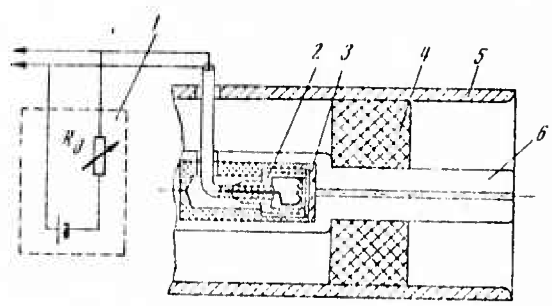

Fig. 2. Bolometer placement in an accelerator.

1 - bolometer feed source; 2 - bolometer; 3 - optical filter; 4 - working material charge; 5 - external electrode, D = 80 mm; 6 - internal electrode, d = 20 mm; length of accelerating zone 40 mm.

jet and the high radiation energy make feasible a plasma focus for generating short duration light flashes with increased ultraviolet radiation output and high energy for optical pumping of laser active media, such as in pulsed photolysis.

Burmakin, V. A., and V. K. Popov. Physical characteristics of electron beam interaction with solids. FiKhOM, no. 6, 1972, 5-13.

Experimental results show that electron bombardment of the local surface of a condensed medium generates a low-temperature, thermally unbalanced ($T_e > T_i = T_a$), dense ($\sim 10^{21} cm^{-3}$) plasma, having an excessive positive charge (10^{-10}-10^{-8} coulomb) and significantly affecting the technological characteristics of electron-beam processing. Based on experimental results and theoretical concepts, a qualitative physical evaluation is given of the following phenomena, usually observed during electron processing:

1. The electron beam penetration in solids is determined by three factors, namely the beam power density in the lateral cross-section; primary electron energy; and duration of the interaction.

2. The increase of the diffusion process is explained by ion motion in an electrostatic field and the inhomogeneity of the plasma ion concentration.

3. The plasma temperature in the lower part of the plasma channel at the solid boundary is higher than in the upper part, which increases the thermodynamic pressure and the ejection of materials from the processing zone.

4. Periodic electron beam deflection is due to the presence of an excessive positive charge of plasma, as a function of plasma temperature.

5. During weak ionization of the materials in the zone of electron beam interaction with solids, the external electric field increases the molecular kinetic energy and decreases the surface ion pressure.

6. The hollow form of crystallized drops of the liquid substances is explained by the positive charge, acquired by the drops from the electron bombardment and from effects of surface tension.

Some graphical and photographic data on beam processing of a tungsten target are included as examples.

Aseyev, G. G., G. G. Kuznetsova, N. S. Repalov, and N. A. Khizhnyak. Parametric instability of an electron beam modulated by an external electrostatic field. ZhTF, no. 11, 1972, 2264-2271.

Experimental data are given on parametric instability of an electron beam modulated by a spatially periodic electrostatic field. Such modulation of dense beams may be used for collective ion acceleration or HF and SHF wave amplification. In the experimental setup (Fig. 1a) energy E_o of the electrostatic modulating field is transferred to the beam under a condition of parametric resonance, which is formulated by the resonance V-I characteristic,

$$I = 1.05 \cdot 10^{-4} \frac{S}{L^2} U_a^{3/2}, \qquad (1)$$

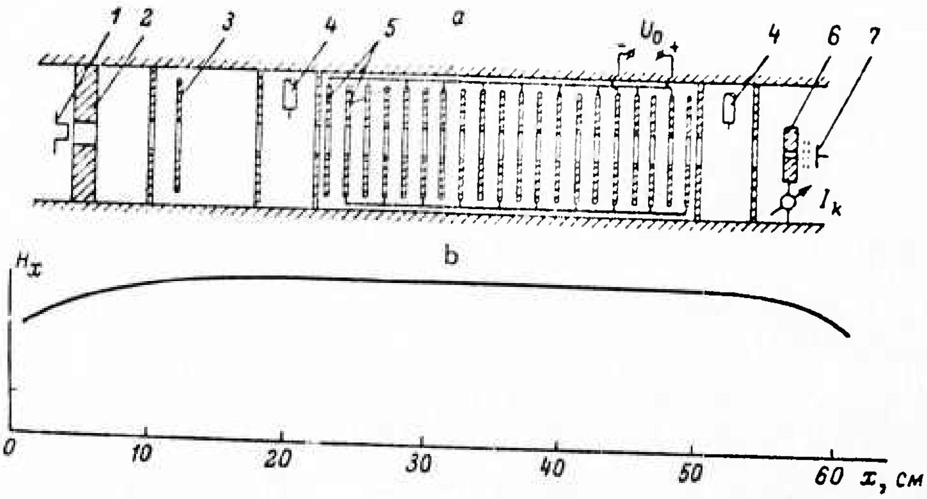

Fig. 1a) experimental setup: 1- cathode, 2- anode, 3- diaphragm of beam HF modulation, 4- probe; 5- diaphragm of the electrostatic modulating field; 6- beam collector, 7- grid detector of electrons; b) magnetic field longitudinal distribution.

Here I is the beam intensity, S is beam cross-section, U_n is the accelerating voltage, and L is the spatial period of the applied field.

The experimental plot of amplitude A of the HF signal versus I (Fig. 2) and the I versus U_n plot at maximum A show a significant resonance

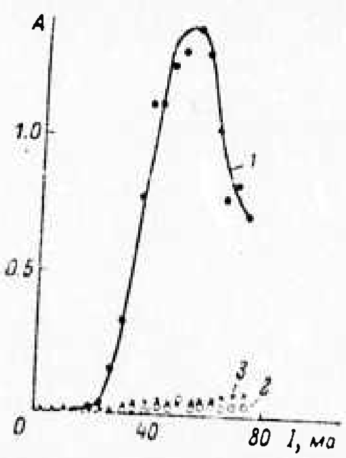

Fig. 2. Amplitude of HF signal picked up by the probe vs. beam I: 1- A(I), U_o = 600 V, n = 10, 2- A(I), U_o = 0 3- A_o(I). Modulation HF = 210 MHz, U = 300 V.

amplification of the HF signal with parametric instability of the electron beam. Instability was observed only when a positive potential U_o was applied to the alternating diaphragms, and only under conditions of current saturation. Instability breaks down in space charge mode operation. The experimental plot of A versus the number n of periods suggests that the observed instability is of convective nature. The magnitude of the instability increment

$$\gamma \simeq \frac{0.16 U_0}{U_n}. \tag{2}$$

is derived from the A versus n and A versus U_o plots at U_n = 300 and 600 V.

Comparison of the γ calculated from (2) with the experimental ln K/K_o values (Fig. 3) shows a satisfactory agreement between the two sets

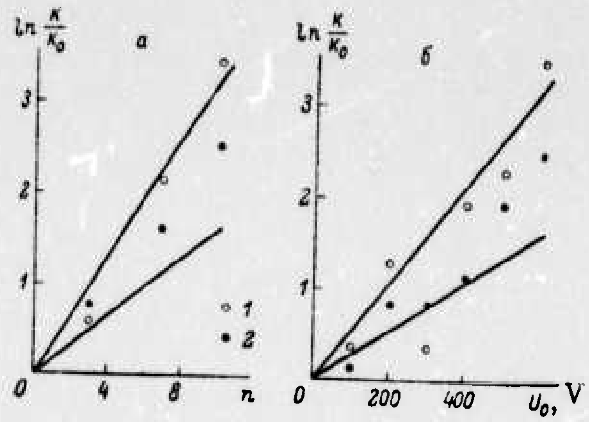

Fig. 3, a) ln K/K_o versus n and b) ln K/K_o versus magnitude of electrostatic field. Solid lines = theory, dots = experiment. Curves 1 and 2- U_n = 300 and 600 V, respectively. Dots are the data obtained from the A vs. n and A vs. U_o plots.

of data ($K = A/A_o$ at $U_o \neq 0$ and K_o is the amplification factor at $U_o = 0$). The amplification factor K in the resonance mode may attain 100. Instability was observed within the $500 \geq \omega/2\pi \geq 50$ MHz frequency range. This range can be expanded towards higher ω by decreasing velocity spread of beam particles, and towards lower ω by modifying the system's geometry.

Kanev, V. G., K. S. Bobev, and Z. D. Mireva. Field emission microscopy of A^IB^V coated tungsten single crystals. DBAN, v. 25, no. 8, 1972, 1029-1032.

A field emission microscopic analysis was made of the surface diffusion or migration of antimony atoms on the surfaces of a tungsten single crystal simultaneously interacting with cesium vapors. Relationships were determined for the average electron work function $\bar{\varphi}$ versus the diffusion time of cesium, interacting with an antimony layer on a tungsten substrate. A temperature of $T \sim 77^\circ$ K was maintained in the substrate and titanium getters during emission image recording for various sorption and thermosorption stages. A platinum current-heated wire was introduced into the projector for convenient dosing of the Cs vapors. The temperatures of the W substrate and the Sb evaporator were determined from the intensity of current passing through the holder with appropriate corrections for cooling at the output. Vacuum pressure was maintained at $p < 1 \times 10^{-9}$ torr. Photos of the W-Sb-Cs system were taken at phases of antimony coating of the tungsten crystals; activation of the W-Sb system in Cs vapors; and emission-image formation of the tungsten crystals with simultaneous evaporation of Sb and Cs.

At T ~ 850-900° K the tungsten surface was completely free of antimony. When the substrate temperature was raised to 420° K, the emission image expanded and migrated over the entire surface; and at ~480° K it regrouped into a bright and stable pattern, typical of an intermetal compound. Desorption of the adsorbate did not begin until temperatures above 900° K. The bond energy between the tungsten and intermetal compound was greater than that between the substrate and any component separately. The variation of work function versus cesium diffusion time for differing quantities of predeposited antimony is shown in Fig. 1. The constancy of $\bar{\varphi}$

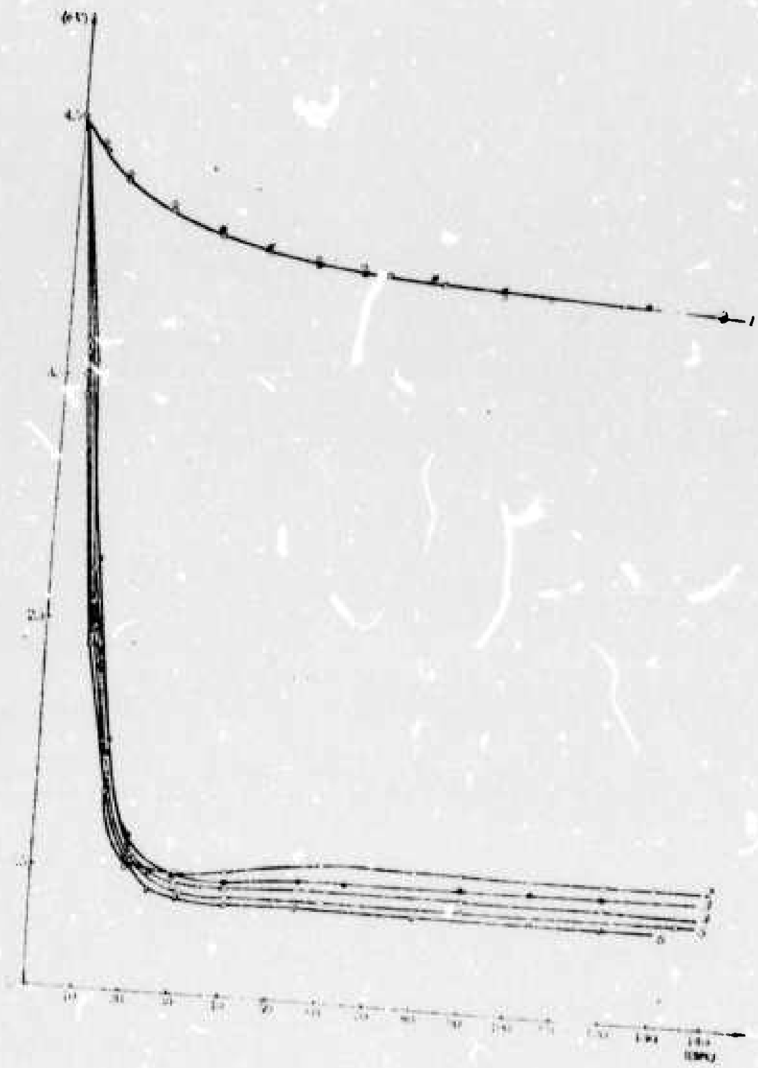

Fig. 1. Relationship of work function to Cs diffusion time.

Curve 1 - coating of W with Sb.
Curve 2 - pure W coated with Cs.
Curve 3-6 - Cs diffusion in Sb layers.

in curves 3-6 after the time necessary (30 sec) for W-Cs system single layer formation shows that in layers differing in conductivity, we have $\chi_o < d$, where χ_o is the Debye-Hueckel shielding radius and d is the layer thickness.

The authors cite two experimental difficulties: 1) a decrease in light emission from the microscope screen owing to the presence of Sb and Cs vapors; and 2) the low work function of the Sb-Cs system ($\bar{\varphi}_{min} \approx 1.50$ eV).

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Syrovatskiy, S. I., A. G. Frank, and A. Z. Khodzhayev. Current distribution near the null magnetic field line and turbulent plasma resistance. ZhTF, no. 5, 1973, 912-924.

5. Material Science

A. Abstracts

Lidorenko, N. S., S. P. Chizhik, Ya. T. Shermazanyan, V. V. Shakhparonyan, T. V. Yefimovskaya, A. A. Lanin, L. A. Lyutsareva and S. P. Shumanova. Preparing transparent zirconium dioxide in a high-temperature solar device. IAN Arm. Seriya tekhnicheskikh nauk, v. 25, no. 4, 1972, 10-13.

Compacted stabilized ZrO_2 specimens were fused in a solar furnace equipped with an automatic sun tracking system using a 1.5 m parabolic mirror (Fig. 1).

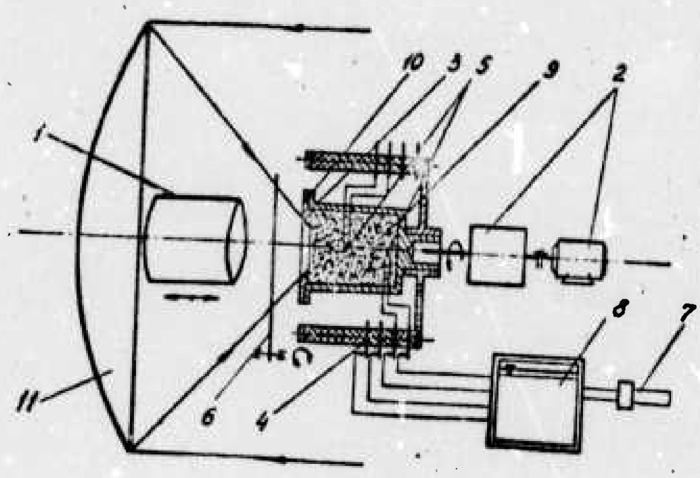

Fig. 1. Solar furnace for fusion study.

1- "internal cylinder" automatic solar power control system, 2- rotary drive, 3- container with uniform rotation speed control, at 0 to 2,000 rpm; 4- contacts for thermocouples, 5- W-Re thermocouples, 6- high-speed chopper, 7- solar radiation sensor, 8- recording potentiometer, 9- specimen, 10- cover with a 17 mm diam. aperture; 11- parabolic mirror.

The fusion experiments were done to explore the feasibility of preparing transparent ZrO_2 in a solar furnace. The container was fastened to the drive shaft in the mirror focal plane and rotated at 1000 rpm. After the solar rays were focused on the mirror, radiant energy in the specimen was rapidly concentrated to a level of 850 w/m^2, at which ZrO_2 begins to melt in 4-5 sec. Axial temperature distribution in the specimen is given for various heating levels. After an additional 4-6 h of heating at this level and subsequent cooling a cylindrical channel was formed in the melting zone. The channel walls were composed of a fused pore-free transparent material, up to 3 mm thick. Micrographs of the fused material revealed large cubic ZrO_2 crystals without impurities or structural defects common in materials prepared by the standard sintering technique. It is thus shown that a transparent, pore-free ZrO_2 material stabilized by various oxides (CaO, Y_2O_3, Se_2O_3) can be prepared relatively simply in a high-temperature solar furnace. The material density is close to theoretical values.

Vasserman, A. A. Calculating thermal conductivity of a gas at high temperatures and pressures. TVT, no. 5, 1972, 1116-1118.

The possibility of formulating a heat conduction equation for a gas expressed as the function $\lambda(p, T)$ where T is temperature and p is pressure, is examined. By analogy with equations for calculating viscosity this can be written in the form

$$\lambda(p, T) = F_1(p) + F_2(p) / T + F_3(p)\lambda(1, T). \tag{1}$$

The first term of Eq. (1) takes into account the increase of heat conductivity

on the isotherm with increased pressure, and the second and the third terms represent the curvature of isobars. Functions Fi(p) are represented by polynomials. In Eq. (1) the temperature function, i. e. the function satisfying the heat conduction equation) corresponds to heat conduction of a gas at atmospheric pressure, or $\lambda(1, T)$, which can be experimentally determined and also can be calculated for a wide range of temperatures using formulas of the kinetic theory of gases.

Eq. (1) can be formed also on the basis of experimental data using the method of least squares or the method of base isotherms. For the application of the latter method it is necessary to have data on the heat conductivity of a compressed gas for three isotherms.

As an illustration, an equation for calculating the heat conductivity of nitrogen for temperatures of 320°-1300° K and pressures 1-1600 bar is formed on the basis of experimental data presented by Johannin (J. rech. Centre nat. rech. scient., No. 43, 116, 1958) taken from the base isotherms 348.15°, 573.15° and 973.15° K. This equation has the form

$$\lambda(1, T) = -1{,}22 + 115{,}9\theta - 109{,}0\theta^2 + 86{,}4\theta^3 - 26{,}9\theta^4. \tag{2}$$

where $\theta = T/1000$. Deviations of heat conductivity calculated values from experimental ones are graphically represented. The possibility of interpolating the derived equation for various temperature and pressure ranges is analyzed.

Men', A. A. Temperature waves in semitransparent medium. TVT, no. 5, 1972, 785-791.

The author notes that no studies have been reported on temperature waves in a semitransparent medium in the presence of radiative and conductive heat transfer. This article accordingly deals with the theoretical study of that problem. To establish the characteristics of the temperature field under radiation-conduction heat transfer, the most simple case is considered: a two-dimensional stratum with the temperature at its boundaries varying according to the harmonic law $T_b = T_r + A \sin\omega t$, where A and ω are the amplitude and frequency respectively of the temperature oscillation about the mean value T_r. It is also assumed that the stratum is bounded by two identical surfaces with identical reflection coefficients and that thermophysical and optical characteristics are constant. The equation for the radiative-conductive heat transfer is taken in the form:

$$-\lambda \frac{\partial^2 T}{\partial x^2} + \frac{\partial E}{\partial x} = -c\gamma \frac{\partial T}{\partial \tau}, \qquad (1)$$

where E is the projection onto the x-axis of the radiation vector; λ is thermal conductivity coefficient, and $c\gamma$ is a heat capacity per unit volume. By introducing the new variable $(x, \tau) = T(x, \tau) - T_n$ and using certain simplifications of Eq. (1) the author obtains a linear integrodifferential equation for (x, τ). For the steady-state case, the solution of this equation takes the form

$$\vartheta(x, \tau) = [u(x) + iv(x)]e^{i\omega\tau}, \qquad (2)$$

and the solution of the problem is reduced to determination of the real and imaginary parts of the complex temperature oscillation amplitude (x, τ).

By substituting (2) into the derived equation, a system of two linear integral equations of the second Fredholm type is derived. Cases are analyzed for which this system can be solved analytically. Numerical solution of the system using Markov's and Simpson's quadrature formulas have been obtained on a BESM-4 computer. The results of solutions for particular cases are presented in 6 graphs.

The results indicate that a temperature field under periodic thermal action and under radiative plus conductive heat transfer, differs substantially from the temperature field under the third kind of regular regime in non-transparent bodies; furthermore, the temperature wave in the semitransparent medium can degenerate.

Tomashevskaya, I. S., and Ya. N. Khamidullin. <u>Feasibility of predicting time of breakdown of rock samples based on crack growth fluctuations.</u> DAN SSSR, v. 207, no. 3, 1972, 580-582.

The article undertakes an experimental varification of the correctness of determining the time t_k of rock samples breakdown from the Baily condition

$$\int_0^{t_k} \frac{dt}{\tau\,[\sigma(t)]} = 1; \qquad (1)$$

where t_k is to be determined and $\tau[\sigma(t)]$ is the functional dependence of the material "lifetime" on the variation of load $\sigma(t)$. This functional dependence is taken in the form

$$\tau\,[\sigma(t)] = \tau_0 \exp\left[\frac{U_0 - \gamma\sigma(t)}{kT}\right], \qquad (2)$$

where τ_o is a pre-exponential factor which is numerically equal to the period of atomic thermal oscillations (10^{-13}-10^{-12} sec); U_o is the energy of the breakdown activization process; γ is a structually-sensitive coefficient, k is an isentropic exponent, and T = absolute temperature.

According to the fluctuation theory of material strength, we then have

$$\gamma = \omega\beta, \qquad (3)$$

where ω is fluctuation (activation) volume and β is stress concentration factor. It is assumed that the rock sample is under compression loads over the entire surface, which are increasing at a constant rate. From Eq. (1) the following expression for t_k is derived:

$$\int_0^{t_k} \frac{dt}{\tau_0 \exp\left[(U_0 - \gamma\dot{\sigma}t)/kT\right]} = 1. \qquad (4)$$

Eq. (4) has been experimentally verified for a series of Kamchatka granite samples under various compression loads. Parameters U_o and γ were determined experimentally by the method presented by Zhurkov (Vestnik ANSSSR, no. 3, 1968). Experimental and calculated results are presented graphically, from which it is shown that experimental and calculated results agree well. A table of U_o, γ and β values for various pressures is given, and their effect upon the breakdown process is analyzed.

Degtyarev, I. S. and V. L. Kolmogorov. Power dissipation and kinematic relationships on the velocity discontinuity surfaces in a compressible rigidly-plastic material. ZhPMTF, no. 5, 1972, 167-173.

Wave surfaces with strong discontinuities in velocity are analyzed in a compressible rigidly-plastic material. A three-dimensional rigidly-plastic body, satisfying plasticity condition of a given form, is taken as the model. It is assumed that in such a body there exists a surface Σ described by the equation $f(x_i, t) = 0$ on which displacement velocities v_i have discontinuities. By applying the principle of maximum energy dissipation rate to plasticity conditions, the condition $[\delta ij] = 0$, where δij is a stress tensor, is derived. From this condition it follows that for convex plasticity conditions on the surface of velocity discontinuities, the stresses in a compressible material are continuous. General expressions are obtained for power dissipation in a thin intermediate layer of the Σ surface, in which velocities v_i have sharp but still continuous changes. On the basis of this expression, the formula defining the dissipation power on the velocity-discontinuous surface of a compressible rigidly-plastic material is derived. As an application of the derived formulas, the steady extrusion process of a rigidly-plastic material from a container through a smooth V-shaped array is analyzed.

Korshak, V. V., A. L. Rusanov, and R. D. Katsarava. Method of manufacturing heat-resistant polymers. Author's certificate, USSR, no. 360688, published October 26, 1970. (Otkr izbr, 36/72, p. 128)

A method is suggested for manufacturing heat-resistant polymers by means of condensation polymerization of tetroamines and dianhydrides of tetracarbonaceous acids. The resulting polyaminoamide acids are then subjected to diazomethane treatment for manufacturing polyaminoamide-ether, which in turn is subjected to heat-treatment to give it a cyclic structure.

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vii. Magnetic Bubble Materials

Chetkin, M. M., and Yu. S. Didosyan. Stripe structure and magnet-optic diffraction in orthoferrites. FTT, no. 4, 1973, 1247-1249.

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6. Miscellaneous Interest

A. Abstracts

French Southern Ocean and Antarctic Regions 1772-1972. Industries et travaux d'Outre-mer, February 1972, 92-108.

A broad review is given of the history, administration, installation of permanent bases, and scientific research presently conducted and planned in the near future at French research bases in this area.

Presently there are four permanent bases: Dumont-d'Urville on Petrel Island, near Adelie Land (French Antarctic Sector); Port-aux-Francais in the Kerguelen archipelago; La Roche Godon on Amsterdam Island, and Alfred Faure in the Crozet Islands. Only basic research has been conducted at these bases. The research program is divided into four principal groups: geomagnetic, geographic, biological, and oceanographic. Only oceanographic research is expected to produce practical results fairly soon in the area of ocean resources exploitation and development of the fishing industry. Scientific data gathered by these research laboratories are transmitted to Paris, by radio; installation is also being studied of an automated system for correction and real-time transmission of recorded data from Kerguelen to Paris. Scientific research in this region is subsidized by the French government through the Ministry of Transoceanic Territories and Departments. In FY 1970 operational and investment expenditures of the scientific services amounted to 5,610,000 francs and 1,550,000 francs respectively. With this general background, the article goes on to outline the objectives and scientific orientation of research in the four principal research areas cited.

In the area of geomagnetic research, the French have established a joint effort with Soviet researchers to exploit the unique position of their Antarctic bases. Thus the Kerguelen base is located on the same

magnetic line of force as the Soviet Sogra base, where analogous scientific installations exist. Joint studies are in progress on the Kerguelen - Sogra conjugate points, and similar studies are scheduled for the Crozet - Pskov and Heard - Dolgoshchel'ye conjugate pairs; these are important, since conjugate pairs with both points occurring on land are relatively rare. Thus far, in the framework of Franco-Soviet cooperation, rockets were launched from Kerguelen in 1968 and balloon-borne measurements were programmed into Project Omega for 1970-1971 from both the Sogra and Kerguelen stations. A Soviet space geodesy team was also authorized by the French government to spend the winter of 1970 on Kerguelen.

A future joint program for magnetospheric studies was agreed upon at the Franco-Soviet colloquium held in July 1969 in Borok, in the Yaroslavl' district, USSR. The main points of this agreement are: concentration and utilization of equipment in ionospheric, magnetic, VLF, and auroral measurements during limited periods; extension of certain recordings to the Crozet and Pskov stations; a summer program on Heard Island (Australia), 250 km south of Kerguelen, and balloon- and rocket-borne experiments. Establishment of direct Kerguelen-Sogra and Kerguelen-Obozierskiy communication lines is foreseen. In this regard, interest is expressed in obtaining magnetospheric data in the vicinity of the Kerguelen - Sogra force line via satellite observations; this would require coordination with satellite controllers to determine time of satellite crossing the Kerguelen - Sogra force tube or, alternatively, to receive the data transmitted by satellite directly at Kerguelen. The latter alternative was judged to be less expensive, so the plan therefore calls for installation at Kerguelen of a receiving station for satellite transmissions. Also, utilization of Kerguelen as the reference time center for all other stations is anticipated, in view of the need to have time standards exact to one millisecond.

During the cited Sixth Plan period, low-frequency (50-500 Hz and 15-300 Hz) emission studies are programmed for the VLF and ULF stations of the Territory. To do this, automated remote recording stations will have to be installed away from the permanent bases, and be connected to the main observatory by telemetry. Present observatories are in Adelie Land (Dumont d'Urville) and in the Kerguelens (Port-aux-Francais), and two geomagnetic stations are installed in the Crozets and on Amsterdam Island. A new isotope-powered station is also under study for Adelie Land. The Dumont d'Urville observatory is located over 1000 km inside the southern auroral zone, near the magnetic pole, whereas the Port-aux-Francais observatory is outside the auroral zone, and hence in a position exceptionally suitable for the study of the Van Allen belts and magnetic perturbations. Muon and neutron detectors have been operational at Kerguelen since July 1957 and, starting in 1962, in Adelie Land as well.

In the geographic research area, a Soviet proposal is discussed for launching meteorological rockets from Kerguelen to study winds and temperatures up to 100 km altitude. According to the plan, Soviet balloons and rockets will be used at Kerguelen and in Adelie Land for weather forecasting; the article includes a photo of a rocket launch from a Soviet vessel at Kerguelen.

In contrast to the cited instances of Franco-Soviet cooperation, a competition appears to be under way over fishing, as evidenced by the concluding remarks. Some time ago a sudden massive intrusion in Australian waters of a modern Soviet fishing fleet prompted French authorities to start fish population counts in the spring of 1973 in these waters. Since December 1970, the permanent presence is mentioned of about 30 Soviet trawlers from Vladivostok and Odessa, which are supported by vessels operating from the Canary Islands. Although not surprising, the presence of so many Soviet vessels generates some apprehension with respect to

Soviet intentions to achieve naval supremacy in the Indian Ocean. The fact that the French sub-Antarctic islands are not demilitarized is seen as a guarantee against repetition of the 1958 troubles caused by Soviet military installations in the Antarctic. The 1972 maneuvers of the French Navy in the Indian Ocean, the visit of the Soviet submarine "Orion" to Mauritius, and American activities at the Diego-Garcia base are all seen as signals of interest displayed by the respective governments towards the geopolitics of the Indian Ocean. The article concludes with the hope that peaceful rather than strategic development will prevail in the region.

COMMENTS:

With reference to the foregoing remarks on the increasing presence of Soviet fishing vessels in the Kerguelen area, a recent source* sheds some light on the ships, research, and future activities involved.

Since 1969, the Azov - Black Sea Scientific Research Institute of Fisheries and Oceanography (Azcher NIRO) has had a four-man team in the Institute's Fisheries Oceanography Laboratory studying the morphology and bottom sediments of the Indian Ocean. This effort has been supplemented by data from nine Indian Ocean fisheries oceanographic expeditions (see Fig. 1) aboard standard and large freezer/trawlers (RTM's and BMRT's). During these cruises, 57,000 nautical miles of echo-sounding tracks were run, and 1537 bottom-sediment samples were taken.

Specifically in the Southern Ocean, there have been four cruises by the fisheries research/reconnaissance ships "Skif" and "Fiolent" between 1969 and 1972. These cruises involved bottom mapping and sampling of the shelf and slopes of Kerguelen, Crozet, and Heard Islands.

Figure 2 below shows completed and planned fisheries-support mapping activities for the Indian and Southern Ocean areas with respect to the type of information format. The "Atlas" mentioned in the legend refers to the "Atlas of Hydrometeordlogical and Fisheries Data on the Tropical Zone of the Western Indian Ocean," Parts I and II.

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* Vorob'yev, S. P., et al. Present state of knowledge of the bottom relief and sediments in the Indian Ocean for fisheries support. Ekspress-informatsiya. Promyslovaya okeanologiya i podvodnaya tekhnika, no. 4, 1973, 12-18.

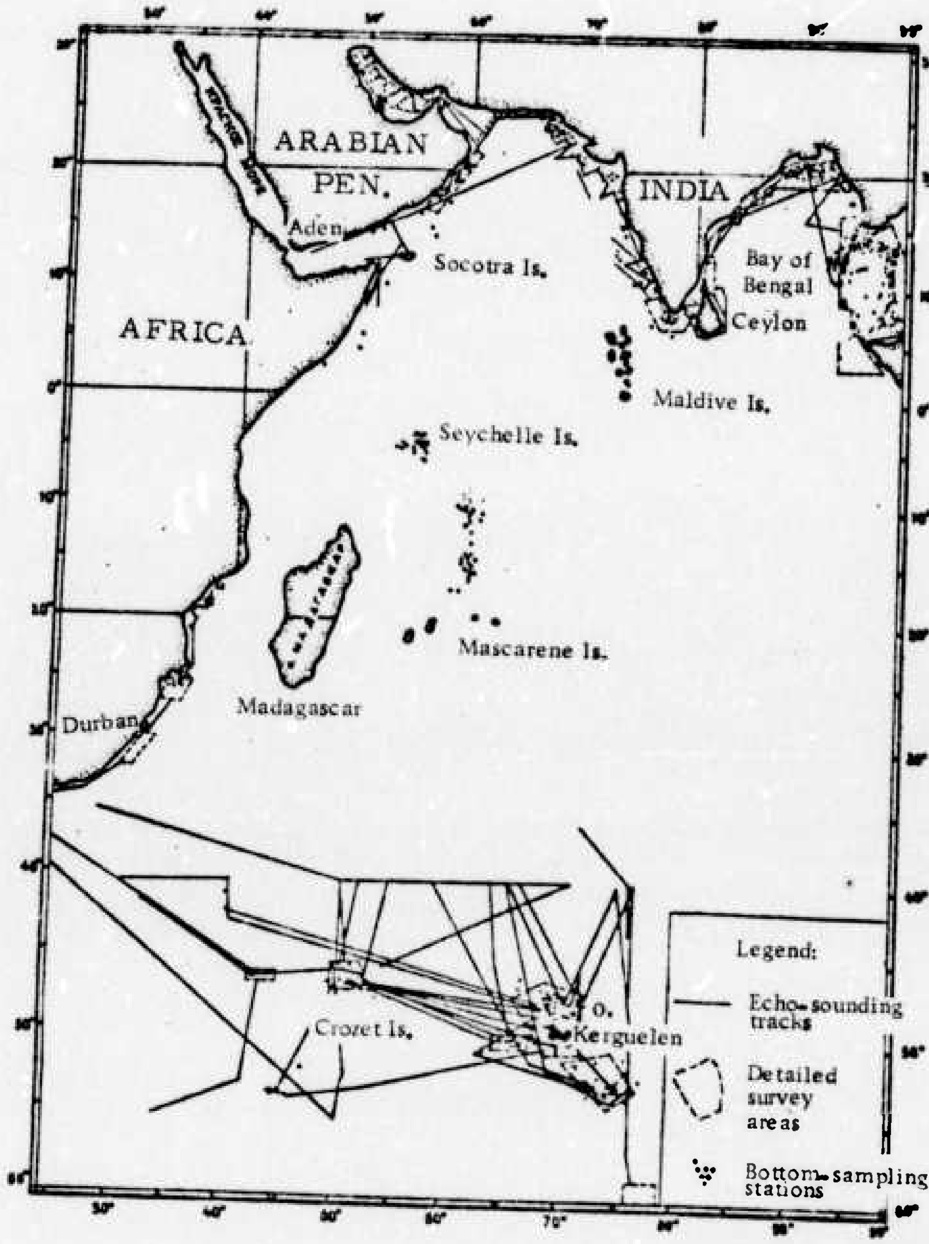

Fig. 1. Geological and Geomorphological Operations in the Indian Ocean.

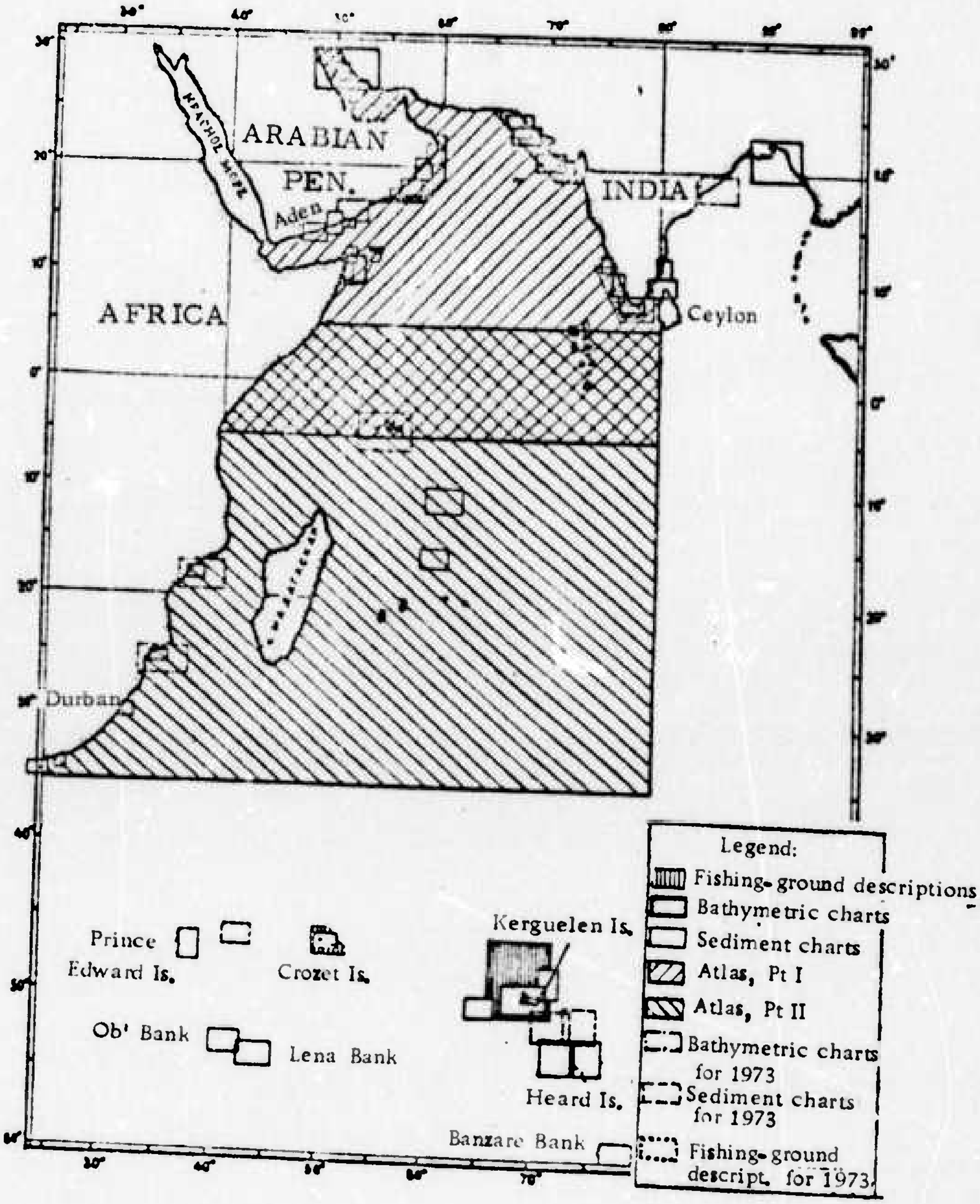

Fig. 2. Guide to Fishing Aids for Indian Ocean Areas.

From 1967 to 1972, AzcherNIRO's cartographic branch has published: 32 fishing charts; 6 fishing-ground descriptions; 54 charts appearing in the above-mentioned "Atlas"; and 10 navigational-fisheries charts (1970).

It is suggested that more research be performed in the central Indian and Southern Oceans to refine and supplement data gathered to date.

Pavlov, O. P. Stereophotogrammetric system for studying the ocean bottom.* Ekspress informatsiya. Promyslovaya okeanologiya i podvodnaya tekhnika, no. 5, 1973, 14-17.

Additional information on the "Skorpena" underwater drone and the "Limb" self-contained underwater stereo camera system is presented. Regarding Skorpena, the following new specs are given: weight (in air) - 0.37 metric tons; displacement - 0.47 metric tons; width - 1.4 m; thickness - 0.37 m; height (without antenna) - 3.5 m; and submersible motor shaft power - 500 watts. The motor is powered by silver-zinc batteries with a capacity of 45 amp-hrs at 27 volts. Continuous motor operation cycles ranging from 6.5 to 20 minutes are preset before launching. Although not stated in the original article, Skorpena should have a "running time" (motor operation only) of about 2.5 hours, assuming a current of about 18 amps and no other drain on the batteries. The normal surfacing system used by Skorpena is a conventional water-ballast blowing system. In addition to previously described emergency surfacing systems and in the event none of them work, a tethered radiobeacon/flashing light capsule can be released to aid in drone recovery. The beacon has a 10-20 km radio range and the light has a 120 joule flash intensity. It is mentioned that instrumentation weighing up to 100 kg can be carried by Skorpena.

The Limb underwater stereo camera system described in the article is used in conjunction with Skorpena. The camera system consists of a cylindrical pressure casing (800 x 219 mm), two telescopic flash lamps, an acoustic transducer used to detect objects entering the

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* Paper presented at the Conference on the Study of the Sea Bottom to Support Fisheries and Navigational and Fisheries Charting, Murmansk, 1972.

depth of focus of the lenses, a depth gage, film counter, and an indicator showing the attitude of the optical axes relative the vertical. The stereo base of the camera is 300 mm, and it uses standard 190 mm wide aerial-camera film, with each stereo-pair frame measuring 60 x 60 mm.

Shipboard processing of stereo pairs is performed on the MSK-1 stereocomparator developed specifically* for shipboard use. The unit measures 510 x 450 x 500 mm, and weighs 17 kg. Measurement accuracy of the x and y coordinates is no worse than 0.01 mm and resolution at the frame center is 85-90 lines/mm.

Medvedev, V. I., and G. I. Kazakov.
Algorithm for optimum siting of ground satellite communication stations. IN:
Trudy Moskovskogo vysshego tekhnicheskogo uchilishcha im. N. E. Baumana, no. 150, 1972, 64-69. (RZhRadiot, 12/72, no. 12A256)
(Translation)

A formula is introduced for estimating the criteria of effective station siting, determined as a function of earth satellite orbital parameters, station coordinates, and their reliability. The obtained function is investigated in the limit for determining optimum station siting; a system of equations is derived which enables determination of optimum station coordinates, comparison of various siting variants, selection of an optimum number of stations, and solution of the problem of their optimum build-up mode.

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* Soviet Patent No. 322616

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Krysin, I. P., R. D. Azelitskaya, and V. F. Chernykh. Effect of magnetically-treated water on properties of solutions and concrete. EOM, no. 1, 1973, 38-40.

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Zhukov, R. F., A. A. Kondratovich, S. D. Mogil'nyy, and B. I. Tsipko. Sistemy, pribory i ustroystva podvodnogo poiska (Systems instruments and assemblies for underwater searching.) Moskva, Voyenizdat, 1972, 182 p. (LC-VKP)

7. SOURCE ABBREVIATIONS

AiT	-	Avtomatika i telemekhanika
APP	-	Acta physica polonica
DAN ArmSSR	-	Akademiya nauk Armyanskoy SSR. Doklady
DAN AzSSR	-	Akademiya nauk Azerbaydzhanskoy SSR. Doklady
DAN BSSR	-	Akademiya nauk Belorusskoy SSR. Doklady
DAN SSSR	-	Akademiya nauk SSSR. Doklady
DAN TadSSR	-	Akademiya nauk Tadzhikskoy SSR. Doklady
DAN UkrSSR	-	Akademiya nauk Ukrainskoy SSR. Dopovidi
DAN UzbSSR	-	Akademiya nauk Uzbekskoy SSR. Doklady
DBAN	-	Bulgarska akademiya na naukite. Doklady
EOM	-	Elektronnaya obrabotka materialov
FAiO	-	Akademiya nauk SSSR. Izvestiya. Fizika atmosfery i okeana
FGiV	-	Fizika goreniya i vzryva
FiKhOM	-	Fizika i khimiya obrabotka materialov
F-KhMM	-	Fiziko-khimicheskaya mekhanika materialov
FMiM	-	Fizika metallov i metallovedeniye
FTP	-	Fizika i tekhnika poluprovodnikov
FTT	-	Fizika tverdogo tela
FZh	-	Fiziologicheskiy zhurnal
GiA	-	Geomagnetizm i aeronomiya
GiK	-	Geodeziya i kartografiya
IAN Arm	-	Akademiya nauk Armyanskoy SSR. Izvestiya. Fizika
IAN Az	-	Akademiya nauk Azerbaydzhanskoy SSR. Izvestiya. Seriya fiziko-tekhnicheskikh i matematicheskikh nauk

IAN B	-	Akademiya nauk Belorusskoy SSR. Izvestiya. Seriya fiziko-matematicheskikh nauk
IAN Biol	-	Akademiya nauk SSSR. Izvestiya. Seriya biologicheskaya
IAN Energ	-	Akademiya nauk SSSR. Izvestiya. Energetika i transport
IAN Est	-	Akademiya nauk Estonskoy SSR. Izvestiya. Fizika matematika
IAN Fiz	-	Akademiya nauk SSSR. Izvestiya. Seriya fizicheskaya
IAN Fizika zemli	-	Akademiya nauk SSSR. Izvestiya. Fizika zemli
IAN Kh	-	Akademiya nauk SSSR. Izvestiya. Seriya khimicheskaya
IAN Lat	-	Akademiya nauk Latviyskoy SSR. Izvestiya
IAN Met	-	Akademiya nauk SSSR. Izvestiya. Metally
IAN Mold	-	Akademiya nauk Moldavskoy SSR. Izvestiya. Seriya fiziko-tekhnicheskikh i matematicheskikh nauk
IAN SO SSSR	-	Akademiya nauk SSSR. Sibirskoye otdeleniye. Izvestiya
IAN Tadzh	-	Akademiya nauk Tadzhiksoy SSR. Izvestiya. Otdeleniye fiziko-matematicheskikh i geologo-khimicheskikh nauk
IAN TK	-	Akademiya nauk SSSR. Izvestiya. Tekhnicheskaya kibernetika
IAN Turk	-	Akademiya nauk Turkmenskoy SSR. Izvestiya. Seriya fiziko-tekhnicheskikh, khimicheskikh, i geologicheskikh nauk
IAN Uzb	-	Akademiya nauk Uzbekskoy SSR. Izvestiya. Seriya fiziko-matematicheskikh nauk
IBAN	-	Bulgarska akademiya na naukite. Fizicheski institut. Izvestiya na fizicheskaya institut s ANEB
I-FZh	-	Inzhenerno-fizicheskiy zhurnal

IiR	-	Izobretatel' i ratsionalizator
ILEI	-	Leningradskiy elektrotekhnicheskiy institut. Izvestiya
IT	-	Izmeritel'naya tekhnika
IVUZ Avia	-	Izvestiya vysshikh uchebnykh zavedeniy. Aviatsionnaya tekhnika
IVUZ Cher	-	Izvestiya vysshikh uchebnykh zavedeniy. Chernaya metallurgiya
IVUZ Energ	-	Izvestiya vysshikh uchebnykh zavedeniy. Energetika
IVUZ Fiz	-	Izvestiya vysshikh uchebnykh zavedeniy. Fizika
IVUZ Geod	-	Izvestiya vysshikh uchebnykh zavedeniy. Geodeziya i aerofotos"yemka
IVUZ Geol	-	Izvestiya vysshikh uchebnykh zavedeniy. Geologiya i razvedka
IVUZ Gorn	-	Izvestiya vysshikh uchebnykh zavedeniy. Gornyy zhurnal
IVUZ Mash	-	Izvestiya vysshikh uchebnykh zavedeniy. Mashinostroyeniye
IVUZ Priboro	-	Izvestiya vysshikh uchebnykh zavedeniy. Priborostroyeniye
IVUZ Radioelektr	-	Izvestiya vysshikh uchebnykh zavedeniy. Radioelektronika
IVUZ Radiofiz	-	Izvestiya vysshikh uchebnykh zavedeniy. Radiofizika
IVUZ Stroi	-	Izvestiya vysshikh uchebnykh zavedeniy. Stroitel'stvo i arkhitektura
KhVE	-	Khimiya vysokikh energiy
KiK	-	Kinetika i kataliz
KL	-	Knizhnaya letopis'
Kristall	-	Kristallografiya
KSpF	-	Kratkiye soobshcheniya po fizike

LZhS	-	Letopis' zhurnal'nykh statey
MiTOM	-	Metallovedeniye i termicheskaya obrabotka materialov
MP	-	Mekhanika polimerov
MTT	-	Akademiya nauk SSSR. Izvestiya. Mekhanika tverdogo tela
MZhiG	-	Akademiya nauk SSSR. Izvestiya. Mekhanika zhidkosti i gaza
NK	-	Novyye knigi
NM	-	Akademiya nauk SSSR. Izvestiya. Neorganicheskiye materialy
NTO SSSR	-	Nauchno-tekhnicheskiye obshchestva SSSR
OiS	-	Optika i spektroskopiya
OMP	-	Optiko-mekhanicheskaya promyshlennost'
Otkr izobr	-	Otkrytiya, izobreteniya, promyshlennyye obraztsy, tovarnyye znaki
PF	-	Postepy fizyki
Phys abs	-	Physics abstracts
PM	-	Prikladnaya mekhanika
PMM	-	Prikladnaya matematika i mekhanika
PSS	-	Physica status solidi
PSU	-	Pribory i sistemy upravleniya
PTE	-	Pribory i tekhnika eksperimenta
Radiotekh	-	Radiotekhnika
RiE	-	Radiotekhnika i elektronika
RZhAvtom	-	Referativnyy zhurnal. Avtomatika, telemekhanika i vychislitel'naya tekhnika
RZhElektr	-	Referativnyy zhurnal. Elektronika i yeye primeneniye

RZhF	Referativnyy zhurnal. Fizika
RZhFoto	Referativnyy zhurnal. Fotokinotekhnika
RZhGeod	Referativnyy zhurnal. Geodeziya i aeros"-yemka
RZhGeofiz	Referativnyy zhurnal. Geofizika
RZhInf	Referativnyy zhurnal. Informatics
RZhKh	Referativnyy zhurnal. Khimiya
RZhMekh	Referativnyy zhurnal. Mekhanika
RZhMetrolog	Referativnyy zhurnal. Metrologiya i izmeritel'naya tekhnika
RZhRadiot	Referativnyy zhurnal. Radiotekhnika
SovSciRev	Soviet science review
TiEKh	Teoreticheskaya i eksperimental'naya khimiya
TKiT	Tekhnika kino i televideniya
TMF	Teoreticheskaya i matematicheskaya fizika
TVT	Teplofizika vysokikh temperatur
UFN	Uspekhi fizicheskikh nauk
UFZh	Ukrainskiy fizicheskiy zhurnal
UMS	Ustalost' metallov i splavov
UNF	Uspekhi nauchnoy fotografii
VAN	Akademiya nauk SSSR. Vestnik
VAN BSSR	Akademiya nauk Belorusskoy SSR. Vestnik
VAN KazSSR	Akademiya nauk Kazakhskoy SSR. Vestnik
VBU	Belorusskiy universitet. Vestnik
VNDKh SSSR	VNDKh SSSR. Informatsionnyy byulleten'
VLU	Leningradskiy universitet. Vestnik. Fizika, khimiya
VMU	Moskovskiy universitet. Vestnik. Seriya fizika, astronomiya

ZhETF	-	Zhurnal eksperimental'noy i teoreticheskoy fiziki
ZhETF P	-	Pis'ma v Zhurnal eksperimental'noy i teoreticheskoy fiziki
ZhFKh	-	Zhurnal fizicheskoy khimii
ZhNiPFiK	-	Zhurnal nauchnoy i prikladnoy fotografii i kinematografii
ZhNKh	-	Zhurnal neorganicheskoy khimii
ZhPK	-	Zhurnal prikladnoy khimii
ZhPMTF	-	Zhurnal prikladnoy mekhaniki i tekhnicheskoy fiziki
ZhPS	-	Zhurnal prikladnoy spektroskopii
ZhTF	-	Zhurnal tekhnicheskoy fiziki
ZhVMMF	-	Zhurnal vychislitel'noy matematiki i matematicheskoy fiziki
ZL	-	Zavodskaya laboratoriya

8. AUTHOR INDEX